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# NBS SPECIAL PUBLICATION 305

## SUPPLEMENT 6

U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

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# PUBLICATIONS

## OF THE NATIONAL BUREAU OF STANDARDS

1974 CATALOG



## NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards<sup>1</sup> was established by an act of Congress March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau consists of the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Institute for Computer Sciences and Technology, and the Office for Information Programs.

**THE INSTITUTE FOR BASIC STANDARDS** provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of a Center for Radiation Research, an Office of Measurement Services and the following divisions:

Applied Mathematics — Electricity — Mechanics — Heat — Optical Physics — Nuclear Sciences<sup>2</sup> — Applied Radiation<sup>2</sup> — Quantum Electronics<sup>3</sup> — Electromagnetics<sup>3</sup> — Time and Frequency<sup>3</sup> — Laboratory Astrophysics<sup>3</sup> — Cryogenics<sup>3</sup>.

**THE INSTITUTE FOR MATERIALS RESEARCH** conducts materials research leading to improved methods of measurement, standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; provides advisory and research services to other Government agencies; and develops, produces, and distributes standard reference materials. The Institute consists of the Office of Standard Reference Materials and the following divisions:

Analytical Chemistry — Polymers — Metallurgy — Inorganic Materials — Reactor Radiation — Physical Chemistry.

**THE INSTITUTE FOR APPLIED TECHNOLOGY** provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government; cooperates with public and private organizations leading to the development of technological standards (including mandatory safety standards), codes and methods of test; and provides technical advice and services to Government agencies upon request. The Institute consists of a Center for Building Technology and the following divisions and offices:

Engineering and Product Standards — Weights and Measures — Invention and Innovation — Product Evaluation Technology — Electronic Technology — Technical Analysis — Measurement Engineering — Structures, Materials, and Life Safety<sup>4</sup> — Building Environment<sup>4</sup> — Technical Evaluation and Application<sup>4</sup> — Fire Technology.

**THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY** conducts research and provides technical services designed to aid Government agencies in improving cost effectiveness in the conduct of their programs through the selection, acquisition, and effective utilization of automatic data processing equipment; and serves as the principal focus within the executive branch for the development of Federal standards for automatic data processing equipment, techniques, and computer languages. The Institute consists of the following divisions:

Computer Services — Systems and Software — Computer Systems Engineering — Information Technology.

**THE OFFICE FOR INFORMATION PROGRAMS** promotes optimum dissemination and accessibility of scientific information generated within NBS and other agencies of the Federal Government; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System; provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world. The Office consists of the following organizational units:

Office of Standard Reference Data — Office of Information Activities — Office of Technical Publications — Library — Office of International Relations.

<sup>1</sup> Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.

<sup>2</sup> Part of the Center for Radiation Research.

<sup>3</sup> Located at Boulder, Colorado 80302.

<sup>4</sup> Part of the Center for Building Technology.



NATIONAL BUREAU OF STANDARDS  
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# Publications of the National Bureau of Standards 1974 Catalog

A Compilation of Abstracts and Key Word and Author Indexes

*Special publication no. 305*

Betty L. Hurdle, Editor

Office of Technical Publications  
National Bureau of Standards  
Washington, D.C. 20234



U.S. DEPARTMENT OF COMMERCE, Rogers C. B. Morton, Secretary

U.S. NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

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**National Bureau of Standards Special Publication 305 Supplement 6**

To Accompany National Bureau of Standards Special Publication 305; and its Supplements 1, 2, 3, 4; and 5

Nat. Bur. Stand. (U.S.), Spec. Publ. 305 Suppl. 6, 523 pages (June 1975)

CODEN: XNBSAV

**Issued June 1975**

U.S. GOVERNMENT PRINTING OFFICE  
WASHINGTON: 1975



## PREFACE

Complete citations for all National Bureau of Standards papers published in both NBS and non-NBS media during 1974 are provided in this annual catalog. They represent the open-literature documentation of NBS research and service activities carried out as part of the Bureau's mission to advance the nation's technology and to apply it for the public benefit. About half of these papers were issued in the Bureau's own publication series; the other half were published in non-NBS technical journals, books, and proceedings.

The citations for all NBS papers, whatever the publication medium, include the full title, author(s), place of publication, abstract, and key words. Permuted author and key word indexes facilitate use of this catalog as a reference source. In addition, a new feature has been incorporated into this issue of the annual catalog: all NBS publications are categorized by major primary subject area. Specialists will find this subject matter listing of NBS papers useful.

Also included is information on previous NBS catalogs, availability information for NBS papers published in past years, and Tables of Contents for the twelve 1974 issues of the Bureau's monthly newsmagazine, DIMENSIONS/NBS.

NBS series papers published by the Government Printing Office are sold by the Superintendent of Documents and also, in microfilm form, by the National Technical Information Service. The complete citations for these publications are organized in this catalog by the respective NBS publications series. NBS-authored papers published in non-NBS media are cited separately in numerical sequence.

Included for the first time among the NBS publications series are citations for the papers which have appeared in the *Journal of Physical and Chemical Reference Data*, published for NBS by the American Institute of Physics and the American Chemical Society.

As were past supplements of NBS Special Publication 305, this 1974 catalog was produced utilizing computer-assisted photocomposition techniques.

W. R. Tilley, *Chief,*  
*Office of Technical Publications*



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# 1. NBS PUBLICATION PROGRAM

## 1.1 INTRODUCTION

The National Bureau of Standards formal publication program provides a principal and effective means of communicating the results of the Bureau's research, development, and service activities to the scientific, technical, and academic community, as well as to the general public. Publications thus constitute a major end product of the Bureau's efforts, totalling about 1200 papers per year. These take the form of the Bureau's three periodicals, its ten nonperiodical publications, NBS interagency reports (NBSIR), and articles in the journals of professional organizations and technological associations.

This book, Publications of the National Bureau of Standards, cites those papers that document the results of the Bureau's current programs; the various media in which these papers appeared are as follows:

## 1.2. PERIODICALS

### 1.2.1. JOURNAL OF RESEARCH

**JOURNAL OF RESEARCH** reports National Bureau of Standards research and development in physics, mathematics, and chemistry. It is published in two sections, available separately:

- **Physics and Chemistry (Section A)**

Papers of interest primarily to scientists working in these fields. This section covers a broad range of physical and chemical research, with major emphasis on standards of physical measurement, fundamental constants, and properties of matter. Issued six times a year.

Editor: C. W. Beckett

Associate Editor: D. D. Wagman

- **Mathematical Sciences (Section B)**

Studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems. Short numerical tables. Issued quarterly.

Editor: M. Newman

Associate Editor: F. W. Olver

### 1.2.2. DIMENSIONS/NBS (formerly Technical News Bulletin)

This monthly magazine is published to inform scientists, engineers, businessmen, industry, teachers, students, and consumers of the latest advances in science and technology, with primary emphasis on the work at NBS. The magazine highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, it reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing.

The table of contents for each issue in 1974 are listed in Section 3.3, pages 33-35. Issued monthly.

Managing Editor: S. A. Washburn

### 1.2.3. JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA (JPCRD)

This journal is published quarterly by the American Chemical Society and the American Institute of Physics for the National Bureau of Standards. The objective of the Journal is to provide critically evaluated physical and chemical property data, fully documented as to the original sources and the criteria used for evaluation. Critical reviews of measurement techniques, whose aim is to assess the accuracy of available data in a given technical area, are also included. The principal source for the Journal is the National Standard Reference Data System (NSRDS). The Journal is not intended as a publication outlet for original experimental measurements such as are normally reported in the primary research literature, nor for review articles of a descriptive or primarily theoretical nature. (See also Section 1.3, NSRDS.)

## 1.3. NONPERIODICALS

Ten categories of nonperiodical publications, described as follows, are listed in this catalog:

**MONOGRAPHS**—major contributions to the technical literature on various subjects



related to the Bureau's scientific and technical activities.

**HANDBOOKS**—recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

**SPECIAL PUBLICATIONS**—Include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

**APPLIED MATHEMATICS SERIES**—mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

**NATIONAL STANDARD REFERENCE DATA SERIES**—provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NBS. Program under authority of National Standard Data Act (Public Law 90-396). See also Section 1.2.3.

**BUILDING SCIENCE SERIES**—disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

**TECHNICAL NOTES**—studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other government agencies.

**VOLUNTARY PRODUCT STANDARDS**—developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The purpose of the standards is to establish nationally recognized requirements for products, and to provide all concerned interests with a basis for common understanding of the characteristics of the products. The National Bureau of Standards administers the Voluntary Product Standards program

as a supplement to the activities of the private sector standardizing organizations.

**FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS (FIPS PUBS)**—publications in this series collectively constitute the Federal Information Processing Standards Register. The purpose of the Register is to serve as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations). FIPS PUBS will include approved Federal information processing standards information of general interest, and a complete index of relevant standards publications.

**CONSUMER INFORMATION SERIES**—practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

#### 1.4. NBS INTERAGENCY REPORTS

A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service (Springfield, Va. 22151) in paper copy or microfiche form.

#### 1.5. NBS BIBLIOGRAPHIC SUBSCRIPTION SERVICES

The Cryogenic Data Center and the Electromagnetics Division of the National Bureau of Standards, Boulder, Colorado have developed specialized bibliographic issuances designed to provide interested audiences with information on latest developments in certain specialized fields. These issuances, together with subscription information, are listed below:

##### *NBS Bibliographic Subscription Services*

**CRYOGENIC DATA CENTER CURRENT AWARENESS SERVICE** (Publications and Reports of Interest in Cryogenics). A literature survey issued weekly. Annual subscription: Domestic, \$20.00; Foreign, \$25.00.



**LIQUEFIED NATURAL GAS.** A literature survey issued quarterly. Annual subscription: \$20.00.

**SUPERCONDUCTING DEVICES AND MATERIALS.** A literature survey issued quarterly. Annual subscription: \$20.00.

Send subscription orders and remittances for the preceding bibliographic services to the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia 22151.

**ELECTROMAGNETIC METROLOGY CURRENT AWARENESS SERVICE** (Abstracts of Selected Articles on Measurement Techniques and Standards of Electromagnetic Quantities from D-C to Millimeter-Wave Frequencies). Issued monthly. Annual sub-

scription: \$100.00 (Special rates for multi-subscriptions). Send subscription order and remittance made payable to the Dept. Comm./NBS to the Electromagnetic Metrology Information Center, Electromagnetics Division, National Bureau of Standards, Boulder, Colorado 80302.

## 1.6. PAPERS PUBLISHED BY OTHERS

Many significant contributions by NBS authors are published in other journals. Up-to-date listings of these articles are carried regularly in each section of the Journal of Research, along with selected abstracts. A complete listing is published annually in NBS SP305, along with abstracts, key words, and author/subject indexes.

## 2. PURCHASE PROCEDURES AND DOCUMENT AVAILABILITY

### 2.1. PURCHASE PROCEDURES

The publications of the Bureau are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at the prices listed in this publication. However, prices are subject to change without notice. You may also order through the U.S. Department of Commerce Field Office nearest you (see Appendix C for list of Field Offices of the U.S. Department of Commerce). Microfiche copies of all recent NBS publications, and paper copies and many non-periodicals, may be ordered through the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151.

This section includes price lists of available publications, plus instruction on how to acquire reprints of articles by NBS authors, and how to get out-of-print material.

**How To Make Remittances.** Remittances for publications for which individual sales or subscription prices are shown should be mailed to Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, by coupon, postal money order, express money order, or check. Postage stamps will not be accepted. Publications cannot be mailed before remittances are received. *Foreign remittances should be made either by international money order or draft on an American bank.*

The letter symbol, publication number, full title of the publication, SD catalog number, and SD stock number **MUST** be given when ordering. The Superintendent of Documents allows a discount of 25 percent on orders of 100 or more copies of one publication.

For the convenience of the general public, coupons in the denomination of five cents may be purchased from the Superintendent of Documents. These may be exchanged for Government publications sold by the Superintendent's office. Address order to Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Persons who make frequent purchases from the Superintendent of Documents may find a deposit account convenient. Deposits of \$25 or more are accepted against which orders may be placed without making individual remittances or first obtaining quotations. Order blanks are furnished for this purpose. After the order has been processed, the order itself is returned, showing the publications supplied, explanations regarding those not sent, the amount of charge, and the balance on deposit.

No charge is made for postage on documents sent to points in the United States and its possessions. In computing foreign postage, add one-fourth of the price of the publication to cover the cost of shipping and handling charges.

Orders for publications purchased from the National Technical Information Service (NTIS) must be accompanied by postal money order, express money order, or check made out to the NTIS and covering total cost of the publications order. Information concerning NTIS coupons can be obtained directly from NTIS. All inquiries or orders should be addressed to: National Technical Information Service, Springfield, Virginia 22151.

SD and NTIS order forms are included at the end of this publication for your convenience in ordering.



## 2.2. ANNOUNCEMENTS OF NBS PUBLICATIONS

The National Bureau of Standards and the agencies mentioned below regularly issue the following official announcements dealing with NBS publications.

**DIMENSIONS/NBS.** Issued monthly by the National Bureau of Standards. In addition to publishing technical news of the Bureau, this periodical announces selected new publications in an NBS series. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription, \$9.45; \$11.85 foreign. Single copies, 65 cents each.

**NBS JOURNAL OF RESEARCH.** Both Sections A and B carry a listing of all NBS publications as issued. See 2.6 for subscription information.

*Monthly Catalog of United States Government Publications.* Issued monthly by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription, with consolidated annual index, \$27.00; \$33.75 foreign.

*Selected List of U.S. Government Publications.* Issued monthly by the Superintendent of Documents. Each list is arranged by subject, with annotations, prices, and order form. May be obtained free from the Superintendent of Documents, Attn: Selected List, P.O. Box 1821, Washington, D.C. 20013.

*Business Service Check List.* Weekly announcement of publications of the Department of Commerce. Lists titles and prices of National Bureau of Standards Publications, as well as those of other offices of the Department of Commerce. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription, \$9.70; \$12.15 foreign.

## 2.3. CATALOGS OF NBS PUBLICATIONS

Previous catalogs, plus this publication, constitute a complete list of the titles of the Bureau's publications through December 31, 1973. The catalogs are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, or may be consulted in a library which

maintains sets of National Bureau of Standards publications.

|                                                                                                                                                                                                                                                               |        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| Circular 460: Publications of the National Bureau of Standards 1901 to June 30, 1947. 375 pages, including subject and author indexes. Brief abstracts are included for the period January 1, 1941 to June 30, 1947.....                                      | \$1.25 |
| Supplement to Circular 460: Publications of the National Bureau of Standards, July 1, 1947 to June 30, 1957. 373 pages, including subject and author indexes.....                                                                                             | \$1.50 |
| Miscellaneous Publication 240: Publications of the National Bureau of Standards July 1, 1957 to June 30, 1960. First NBS Catalog to Include Titles of Papers Published in Outside Journals 1950 to 1959. 391 pages, including subject and author indexes..... | \$3.50 |
| Supplement to Miscellaneous Publication 240: Publications of the National Bureau of Standards published by NBS, July 1960 through June 1966; published by others, 1960 through 1965. 740 pages, including subject and author indexes.....                     | \$4.00 |
| Special Publication 305: Publications of the National Bureau of Standards, published by NBS. July 1966 through December 1967; published by others, 1966-1967. 223 pages, a citation of titles and abstracts, with key words and author indexes.....           | \$2.00 |
| Supplement 1 to Special Publication 305: Publications of the National Bureau of Standards, 1968 through 1969. 497 pages, a citation of titles and abstracts, with key words and author indexes.....                                                           | \$5.55 |
| Supplement 2 to Special Publication 305: Publications of the National Bureau of Standards, 1970. 378 pages, a citation of titles and abstracts, with key words and author indexes.....                                                                        | \$4.30 |
| Supplement 3 to Special Publication 305: Publications of the National Bureau of Standards, 1971. 342 pages, a citation of titles and abstracts, with key words and author indexes.....                                                                        | \$3.95 |
| Supplement 4 to Special Publication 305: Publications of the National Bureau of Standards, 1972. 449 pages, a citation of titles and abstracts, with key words and author indexes.....                                                                        | \$4.20 |
| Supplement 5 to Special Publication 305: Publications of the National Bureau of Standards, 1973. 349 pages, a citation of titles and abstracts, with key words and author indexes.....                                                                        | \$4.15 |
| Supplement 6 to Special Publication 305: Publications of the National Bureau of Standards, 1974. 523 pages, a citation of titles and abstracts, with key words and author indexes.....                                                                        | \$6.80 |

## 2.4. FUNCTIONS OF DEPOSITORY LIBRARIES IN THE UNITED STATES

The Superintendent of Documents, United States Government Printing Office, is authorized by law to furnish Government publications to designated depository libraries.

Under provisions of Title 44 of the United States Code, certain libraries are designated depositories for Government publications. Through them Federal Government documents are made available to residents of every State, District of Columbia, Guam,



Puerto Rico, and the Virgin Islands. Distribution to the libraries is made by the Office of the Superintendent of Documents.

It is sometimes impossible to obtain desired publications by purchase from the Superintendent of Documents. Stocks may have been exhausted or the document may be permanently out of print. In these instances the depositories render an invaluable service by keeping such publications permanently available. Every Government publication cannot be consulted at all depository libraries. Designated Regional Depositories are required to receive and retain one copy of all Government publications made available to depository libraries either in printed or microfacsimile form. All other libraries are allowed to select the classes of publications best suited to the interests of their particular clientele.

The libraries listed in Appendix A are now receiving selected publication series of the National Bureau of Standards for general reference use. Whether a given library has a copy of a particular publication can be determined by inquiring at the library.

## 2.5. FUNCTIONS OF U.S. DEPARTMENT OF COMMERCE FIELD OFFICES

Department of Commerce Field Offices are maintained in the cities listed in Appendix B. Their purpose is to provide ready access, at the local level, to the services of the Department of Commerce as well as to its reports, publications, statistical statements, and surveys. Each Field Office serves as an official sales agent of the Superintendent of Documents, U.S. Government Printing Office, making available for purchase locally a wide range of Government publications. The reference library maintained by each Field Office contains many Government and private publications, periodicals, directories, reports, and other reference materials.

## 2.6. AVAILABILITY OF NBS PUBLICATIONS

### A. PERIODICAL SUBSCRIPTION RATES

| Periodical                                                                                                                            | Domestic <sup>1</sup> | Foreign <sup>2</sup> |
|---------------------------------------------------------------------------------------------------------------------------------------|-----------------------|----------------------|
| Journal of Research of the National Bureau of Standards: Section A. Physics and Chemistry, issued six times a year, paper covers..... | \$17.00               | \$21.25              |
| Bound volume (1 volume per year), blue buckram.....                                                                                   | ( <sup>3</sup> )      | ( <sup>3</sup> )     |
| Section B. Mathematical Sciences, issued quarterly, paper covers.....                                                                 | 9.00                  | 11.25                |
| Bound volume (1 volume per year), green buckram...                                                                                    | ( <sup>3</sup> )      | ( <sup>3</sup> )     |
| DIMENSIONS/NBS, 12 monthly issues.....                                                                                                | 9.45                  | 11.85                |

NOTE.—Send order, with remittance, to Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

<sup>1</sup>United States and its possessions, Canada, Mexico, Newfoundland (including Labrador), and certain Central and South American countries.

<sup>2</sup>Foreign price includes the cost of the publication and postage.

<sup>3</sup>Prices of the bound volumes vary. The Superintendent of Documents will furnish prices on request.

### B. PRICE LISTS FOR NONPERIODICALS

The following lists give the numbers and prices of all NBS publications issued from 1901 through 1974 which are still in print. Those items in **boldface** denote the 1974 publications cited in this supplement. The prices shown herein supersede prices quoted in previous catalogs of NBS publications. The prices shown are those in effect as of the date this publication went to press. Prices are subject to change without notice, and the prices that will be charged on your order will be those in effect as of the date your order is processed. Publications may be ordered from the Superintendent of Documents, U.S. Government Printing Office or from the U.S. Department of Commerce Field Office nearest you. SD order forms are included at the end of this publication. Some NBS publications may be purchased from the National Technical Information Service. (See Section 2.1.)

Publications not listed are out of print. In such cases, your nearest depository library may still have a copy of that item. (See Section 2.4 and Appendix A.)



PRICE LISTS  
NBS PUBLICATIONS  
CIRCULARS

| No.                                    | Price | No.                                                   | Price | No.                                                      | Price |
|----------------------------------------|-------|-------------------------------------------------------|-------|----------------------------------------------------------|-------|
| 17 see Mono. 47<br>(COM 71-00691)..... | *     | 465 see H90<br>(PB188654).....                        | **    | 533 see SP374.....                                       | 3.25  |
| 25 see SP260.....                      | 1.30  | 466 see H71.....                                      | *     | 536.....                                                 | .55   |
| 31 see H100.....                       | *     |                                                       |       | 537 see NSRDS-<br>NBS 10.....                            | .95   |
| 47 see M286.....                       | 2.25  | 467 Vol. I see<br>NSRDS 35 Vol. I.....                | 9.25  | 539 Vol. 1 to 10 are<br>now PB178902 to<br>PB178911..... | **    |
| 57 see C410.....                       | *     | 467 Vol. II see<br>NSRDS 35 Vol. II.....              | 7.95  |                                                          |       |
| 61 see H44, 4th Ed.....                | 5.40  | 467 Vol. III see<br>NSRDS 35 Vol. III.....            | 8.30  | 542 (PB188806).....                                      | **    |
| 154 see H71.....                       | *     |                                                       |       | 552 see SP260.....                                       | 1.30  |
| 390 see H71.....                       | *     | 474 see C576.....                                     | *     | 553 (COM73-11112).....                                   | **    |
| 398 see SP260.....                     | 1.30  | 495 see Mono. 88.....                                 | .85   | 556 (PB172004).....                                      | **    |
| 402.....                               | .25   | 499.....                                              | *     | 559 see H71.....                                         | *     |
| 410.....                               | *     | 500 see TN270-3; 4;<br>5; 6; 7; & 8                   |       |                                                          |       |
| 414 see H71.....                       | *     |                                                       |       | 561 see Mono. 125.....                                   | 4.55  |
| 415 see Mono. 47.....                  | **    | 506 see C576.....                                     | *     | 564.....                                                 | *     |
| 428 see SP374.....                     | 3.25  | 510 (PB192339).....                                   | **    | 571 (PB175659).....                                      | **    |
| 435 see H71.....                       | *     | 510 Suppl. 1<br>(PB192340).....                       | **    | 576.....                                                 | *     |
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| 700.....               | 1.30  | 738.....                | .40   | 782.....               | .90   |
| 702.....               | .85   | 739.....                | .65   | 783.....               | 1.05  |
| 703.....               | .85   | 740.....                | .55   | 785.....               | .70   |
| 705 see TN762.....     | 1.55  | 742.....                | .95   | 786.....               | .50   |
| 706.....               | .55   | 743.....                | 1.00  | 787.....               | .90   |
| 707.....               | .55   | 744.....                | .55   | 788.....               | 1.15  |
| 708 (COM72-50062)..... | *     | 745.....                | .75   | 789.....               | 2.35  |
| 709.....               | .55   | 746.....                | 2.00  | 790.....               | .75   |
| 710-1.....             | .55   | 747.....                | 1.25  | 791.....               | .30   |
| 710-2.....             | .60   | 748.....                | .60   | 792.....               | .80   |
| 710-3.....             | .60   | 749.....                | 1.50  | 793.....               | .50   |
| 710-4.....             | .90   | 751.....                | .85   | 794.....               | 1.60  |
| 710-5.....             | .95   | 752.....                | .95   | 795.....               | 1.00  |
| 710-6.....             | 1.00  | 753.....                | 1.10  | 796.....               | .80   |
| 710-7.....             | 1.30  | 754.....                | .95   | 797.....               | .50   |
| 711 (COM72-50064)..... | *     | 755.....                | .70   | 798.....               | 1.70  |
| 712.....               | .55   | 756.....                | .85   | 799.....               | .85   |
| 713.....               | .60   | 757.....                | .45   | 800.....               | .60   |
| 714.....               | 1.50  | 758.....                | 2.10  | 801.....               | .60   |
| 715.....               | 1.45  | 759.....                | .65   | 802.....               | .60   |
| 716.....               | 1.55  | 760.....                | .90   | 803.....               | .80   |
| 717.....               | .95   | 761.....                | 1.15  | 804.....               | 1.55  |
| 718.....               | .70   | 762.....                | 1.55  | 805.....               | 1.20  |
| 719.....               | .95   | 763.....                | .65   | 806.....               | 1.15  |
| 720.....               | .65   | 764.....                | .65   | 807.....               | 1.80  |
| 721.....               | 2.05  | 765.....                | .60   | 808.....               | 1.95  |
| 722.....               | 1.00  | 766.....                | .85   | 809.....               | .85   |
| 723.....               | .85   | 769.....                | 2.10  | 810.....               | .50   |
| 724.....               | 1.40  | 770.....                | 1.40  | 811.....               | 1.00  |
| 725.....               | .75   |                         |       |                        |       |
| 726 (AD-748-788).....  | *     |                         |       |                        |       |

\* Available from the National Technical Information Service; used "AD" or "COM" number when ordering.



# TECHNICAL NOTES – Continued

| No.      | Price | No.      | Price | No.      | Price |
|----------|-------|----------|-------|----------|-------|
| 812..... | .65   | 826..... | .90   | 840..... | .55   |
| 813..... | 1.55  | 827..... | 1.25  | 841..... | .60   |
| 814..... | .90   | 828..... | 1.70  | 842..... | 1.25  |
| 815..... | .60   | 829..... | 1.10  | 843..... | 1.50  |
| 816..... | .85   |          |       | 844..... | .70   |
|          |       | 830..... | .65   |          |       |
| 817..... | .60   | 831..... | .95   | 845..... | .75   |
| 818..... | .60   | 832..... | .70   | 847..... | .80   |
| 819..... | 1.20  | 833..... | 1.20  | 848..... | .55   |
| 820..... | .90   | 834..... | .55   | 849..... | .80   |
| 821..... | .60   |          |       | 850..... | .85   |
|          |       | 835..... | 1.95  |          |       |
| 822..... | 1.50  | 836..... | .65   | 851..... | .80   |
| 823..... | .60   | 837..... | 2.15  | 852..... | .85   |
| 824..... | .65   | 838..... | 1.45  | 853..... | .85   |
| 825..... | 1.25  | 839..... | 1.55  |          |       |

## SOURCES FOR REPRINTS OF NBS PAPERS IN PERIODICALS

| SOURCES                                                       | TYPE OF PAPER                                                  |                                                        |                                         |
|---------------------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------|-----------------------------------------|
|                                                               | NBS Journal<br>Research Papers <sup>1</sup><br>Prior July 1959 | NBS Journal<br>Research Papers<br>July 1959 to Present | NBS-Authored<br>Papers<br>non-NBS Media |
| Superintendent of Documents, GPO                              |                                                                | See Footnote <sup>3</sup>                              |                                         |
| National Technical Information<br>Service (NTIS) <sup>2</sup> | See Footnote <sup>5</sup>                                      |                                                        |                                         |
| Author                                                        |                                                                | X                                                      | X                                       |
| Federal Depository Libraries <sup>4</sup>                     | X                                                              | X                                                      |                                         |
| Library of Congress <sup>6</sup>                              | X                                                              | X                                                      | X                                       |
| Original Media                                                |                                                                |                                                        | X                                       |

<sup>1</sup> RESEARCH PAPERS were reprints of individual articles that appeared in Volumes 1-62 of the monthly Journal of Research. These papers were published, numbered, and made available separately. In 1959 NBS began publishing the Journal of Research in separate sections, and RESEARCH PAPERS were discontinued.

<sup>2</sup> Address: National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22151.

<sup>3</sup> Bound volumes or (when available) the individual Journals may be purchased. See price list above.

<sup>4</sup> Primarily for reference; some libraries are equipped to reproduce copies for a fee. See Appendix A for list.

<sup>5</sup> Hard copy available and microfiche copies also available. See footnote (2) for address.

<sup>6</sup> Photoduplication Service, Library of Congress, Washington, D.C. 20540.

## C. SUPERSEDED NBS REFERENCE PUBLICATIONS

Those NBS Publications not listed in the Price Lists, are out of print and are not available from the Superintendent of Documents. Many can be consulted at libraries. Also, in many cases, photoduplicated copies can be purchased from the Library of Congress. For full information concerning this service, write to the Photoduplication Service, Library of Congress, Washington, D.C. 20540.

Certain NBS publications are out of print because they have been replaced, or partially replaced, by material issued by other organizations. In this connection NBS is able to offer the following information:

*Circular 410, National Standard Petroleum Oil Tables.* Information in this Circular has been incorporated in the ASTM-IP Petroleum Measurement Tables issued by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103. Available at \$12.75, 20% off to ASTM members. Tables 5 and 7 of the ASTM-IP Tables may also be purchased from the ASTM in separate reprint form at \$1.75 and \$1.50 per copy respectively.

*Circular 438, Static Electricity.* The National Fire Protection Association, 60 Batterymarch Street, Boston, Mass. 02110, has issued a publication by the same title, available from them as NFPA Publication 77, at \$2.00.

*Circular 464, Gas Calorimeter Tables.* The American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103, has issued a publication on this subject. Listed as ASTM D900-55, it can be ordered at \$1.75 per copy.

*Circular 499, Nuclear Data.* Replaced by Atomic and Nuclear Data Tables, published by Academic Press, 111 Fifth Avenue, New York, N.Y. 10003. Available by subscription for \$69.00 per year.

*Circular 564, Tables of Thermal Properties of Gases.* A reprinted edition is available from University Microfilms, Inc., Ann Arbor, Michigan 48106. Order as OP 12,192 for \$25.00. Microfiche of this Circular is available from Cryogenic Data Center, National Bureau of Standards, Boulder, Colorado 80302 for \$4.50.

*Circular 576, Automotive Antifreezes.* For information on this subject consult American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

*Circular 577 and Supplement, Energy Loss and Range of Electrons and Positrons.* These have been superseded by NASA Spe-

cial Publication 3012, available from the National Technical Information Service, Springfield, Va. 22151, at \$5.75 hardcopy and \$2.25 microfiche Number N65-12506.

*Miscellaneous Publication 179, American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures.* The American National Standards Institute, 1430 Broadway, New York, N.Y. 10018, has issued a publication on this subject. Available from them as A58.1-1969, at \$7.50.

*Miscellaneous Publication 187, Directory of Commercial and College Laboratories.* A new Director of College and Commercial Testing Laboratories is published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103, at \$3.75.

*Miscellaneous Publication 211, American Standards Building Code Requirements for Masonry.* The American National Standards Institute, 1430 Broadway, New York, N.Y. 10018, has issued a publication on this subject. Available from them as A41.1-1953-R1970, at \$3.25.

*Handbook 30, National Electrical Safety Code (also H81 and its Supplements and H110-1).* The American National Standards Institute, 1430 Broadway, New York, N.Y. 10018, has issued a publication on this subject. Available from them as ANS C2, at \$5.50.

*Handbook 46, Code for Protection Against Lightning.* A United States of America Standards Institute Code for Protection Against Lightning (NFPA-78-1969) is available from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018, at \$1.25, as C5.1-1969.

*Handbook 48, Control and Removal of Radioactive Contamination in Laboratories.* Reprints of this Handbook can be purchased as NCRP Report 8 at \$2.00 from NCRP Publications, Post Office Box 30175, Washington, D.C. 20014.

*Handbook 49, Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medical Users.* Reprints of this Handbook can be purchased as NCRP Report 9 at \$2.00 from NCRP Publications, Post Office Box 30175, Washington, D.C. 20014.

*Handbook 58, Radioactive Waste Disposal in the Ocean.* Reprints of this Handbook can be



purchased as NCRP Report 16 at \$2.00 from NCRP Publications, Post Office Box 30175, Washington, D.C. 20014.

*Handbook 59, Permissible Dose from External Sources of Ionizing Radiations.* Reprints of this Handbook can be purchased as NCRP Report 39 at \$4.00 per copy from NCRP Publications, Post Office Box 30175, Washington, D.C. 20014.

*Handbook 63, Protection Against Neutron Radiation up to 30 MeV.* Reprints of this Handbook can be purchased as NCRP Report 38 at \$5.00 per copy from NCRP Publications, Post Office Box 30175, Washington, D.C. 20014.

*Handbook 65, Safe Handling of Bodies Containing Radioactive Isotopes.* Reprints of this Handbook can be purchased as NCRP Report 37 at \$4.00 per copy from NCRP Publications, Post Office Box 30175, Washington, D.C. 20014.

*Handbook 71, Specifications for Dry Cells and Batteries.* Available as C18.1-1972 from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018, at \$6.25.

*Handbook 73, Protection Against Radiations from Sealed Gamma Sources* (Supersedes H54). Reprints of this Handbook can be purchased as NCRP Report 40 at \$4.00 per copy from NCRP Publications, Post Office Box 30175, Washington, D.C. 20014.

*Handbook 74, Building Code Requirements for Reinforced Masonry.* The American National Standards Institute, 1430 Broadway, New York, N.Y. 10018 has issued a publication on this subject. Available from them as A41.2-1960 (R1970), at \$3.25.

*Handbook 75, Measurement of Absorbed Dose of Neutrons and of Mixtures of Neutrons and Gamma Rays.* Reprints of this Handbook can be purchased as NCRP Report 25 at \$2.00 per copy from NCRP Publications, Post Office Box 30175, Washington, D.C. 20014.

*Handbook 76, Medical X-ray Protection Up to Three Million Volts.* Now NCRP 33 and 34 respectively. Purchase from NCRP Publications, Post Office Box 30175, Washington, D.C. 20014.

*Handbook 81 and its Supplements, Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines* (also H30 and H110-1). The American National Standards Institute, 1430 Broadway, New York, N.Y. 10018 has issued a publication on this subject. Available from them as ANS C2, at \$5.50.

*Handbook 84, Radiation Quantities and Units,* has been superseded by ICRU Report 19 at \$2.50 per copy from ICRU Publications, Post Office Box 30165, Washington, D.C. 20014.

*Handbook 89, Methods of Evaluating Radiological Equipment and Materials.* Reprints of this Handbook can be purchased as ICRU Report 10F at \$2.50 per copy from ICRU Publications, Post Office Box 30165, Washington, D.C. 20014.

*Handbook 97, Shielding for High-Energy Electron Accelerator Installations.* Reprints of this Handbook can be purchased as NCRP Report 31 at \$1.00 per copy from NCRP Publications, Post Office Box 30175, Washington, D.C. 20014.

*Handbook 102, ASTM Metric Practice Guide.* American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103, has issued a publication as Document E380-72, at \$1.75.

*Handbook 110-1, National Electrical Safety Code.* Part 1. Rules for Installation and Maintenance of Electric Supply and Communication Lines (also H30 and H81 and its Supplements). The American National Standards Institute, 1430 Broadway, New York, N.Y. 10018 has issued a publication on this subject. Available from them as ANS C2, at \$5.50.

### 3. TITLES AND ABSTRACTS OF NBS PUBLICATIONS, 1974<sup>1</sup>

#### 3.1. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION A. PHYSICS AND CHEMISTRY, VOLUME 78A, JANUARY-DECEMBER 1974

##### January-February 1974

**Thermophysical measurements on iron above 1500 K using a transient (subsecond) technique**, A. Cezairliyan and J. L. McClure, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 1, 1-4 (Jan.-Feb. 1974).

Key words: electrical resistivity; emittance; heat capacity; high-speed measurements; high temperature; iron; melting point; phase transformation; thermodynamics; thermophysical properties.

Simultaneous measurements of heat capacity, electrical resistivity and hemispherical total emittance of iron (99.9% pure) in the temperature range 1500 to 1800 K, and the melting point of iron by a subsecond duration, transient technique are described. The measurements indicate increases in heat capacity and electrical resistivity as the result of the solid-solid phase transformation ( $\gamma \rightarrow \delta$ ) in iron. The measured value of the hemispherical total emittance at 1720 K is 0.33. The average of the results of two experiments yield a value of 1808 K for the melting point of iron. Estimated inaccuracies of measured properties are: 3 percent for heat capacity and emittance, 1 percent for electrical resistivity, and 5 K for the melting point.

**Measurement of melting point, normal spectral emittance (at melting point) and electrical resistivity (near melting point) of some refractory alloys**, A. Cezairliyan, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 1, 5-8 (Jan.-Feb. 1974).

Key words: alloys; electrical resistivity; high temperature; melting point; normal spectral emittance; refractory materials; thermophysics.

A subsecond duration pulse heating method is used to measure the melting point, normal spectral emittance (at the melting point, corresponding to 650 nm), and electrical resistivity (near the melting point) of the following refractory alloys: 90 Ta-10W, 99 Nb-1 Zr, and 80 Nb-10 Ta-10 W (numbers indicate nominal composition in percentage by weight). The melting point and the normal spectral emittance are:  $3286 \pm 15$  K and 0.396 for 90 Ta-10 W,  $2737 \pm 10$  K and 0.351 for 99 Nb-1 Zr, and  $2814 \pm 10$  K and 0.333 for 80 Nb-10 Ta-10 W. The inaccuracy of the normal spectral emittance and electrical resistivity results is estimated to be 3 percent and 0.5 percent, respectively.

**Comparative density measurements for solid specimens weighing a few milligrams**, A. D. Franklin and J. R. Donaldson, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 1, 9-13 (Jan.-Feb. 1974).

Key words:  $\text{CaF}_2$ ; density; measurement technique; Si; tungsten wires.

A density comparison technique previously described has been used to compare the densities of tungsten wires weighing

about 1.3 mg to within a few percent error. For larger, less dense specimens the expected random error of a few parts in  $10^4$  was confirmed by comparing the known densities of Si and  $\text{CaF}_2$ .

**A density scale based on solid objects**, H. A. Bowman, R. M. Schoonover, and C. L. Carroll, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 1, 13-40 (Jan.-Feb. 1974).

Key words: density standard; hydrostatic weighing; perfect sphere; silicon; spherical interferometer; spherical volume; volume standard.

We have determined the density of four pieces of single crystal silicon in terms of universally accepted standards of mass and length. These four objects will be used as a working density standard to which all future density work in the United States will be referred. Using these crystals as standards, NBS can calibrate other objects as density standards for associated laboratories.

The work was accomplished with the assistance of an interferometer, developed especially for the task, which measures the diameter of commercially available steel balls. From measured diameters ball volumes are calculated. The volumetric information contained in the balls is transferred to the silicon crystals in a newly designed hydrostatic weighing experiment.

We have made three independent density determinations on each of the four crystals, and the presently accepted values of the density of each crystal is the average of the three determinations. The random component of uncertainty (3 standard deviations) of these four averages is 0.7 ppm. The systematic error is estimated to be about 0.7 ppm.

**Geometrical considerations in the measurement of the volume of an approximate sphere**, D. P. Johnson, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 1, 41-48 (Jan.-Feb. 1974).

Key words: asphericity correction; density; spherical harmonics; volume of ball.

Expressions are derived for the volume of an approximate sphere in terms of measured breadth, the distance between parallel planes tangent to opposite sides. The difference in volume of a ball and a true sphere of the same average breadth is shown to be of second order, and much smaller than the random and systematic errors in the measurements of the dimension. Thus, a ball commercially available at moderate cost can be used for absolute density measurements of high accuracy. Similar expressions are given for the area of an approximate circle.

**Note on diffusion of vapor into flowing gas**, D. P. Johnson, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 1, 49-51 (Jan.-Feb. 1974).

Key words: diffusion; equilibrium; evaporation; humidity; humidity generator; laminar flow; saturation; water vapor.

The theory of diffusion of vapor between the walls of a tube and a stream of gas is applied to a generator of known humidities. The rate of approach to equilibrium is evaluated for gas velocities in the laminar flow range. The effect of pressure drop is examined.

<sup>1</sup> The various NBS publications series are grouped under subheadings within this section. The several volumes of the Journal of Research are presented consecutively within their appropriate subheadings. If a particular publications series is sought, consult the table of contents or the edge index on the back cover.



**Theoretical analysis of miscibility gaps in the alkali-borates**, P. B. Macedo, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 1, 53-59 (Jan.-Feb. 1974).

Key words: glass; immiscibility; phase separation; thermodynamics of solutions.

A thermodynamic approach based on the regular solution concept is applied to the description of miscibility gap boundaries in the alkali-borate systems. It is suggested that in each system the structural units which control the entropy of mixing are the stoichiometric compounds at the apparent limit of the alkali-rich edge of the gap, and a complex boron trioxide structure. (The former is inferred by the shape of the gap, and the latter is chosen to fit the regular mixing equation.) The same boron trioxide complex is used for all the systems analyzed. The physical implications of this analysis are discussed.

### March-April 1974

**The formation of curved polymer crystals: Polyoxymethylene**, F. Khoury and J. D. Barnes, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 2, 95-127 (Mar.-Apr. 1974).

Key words: chain-folded; crystal; curved; electron microscopy; optical microscopy; polymer; polyoxymethylene; solution grown.

An optical and electron microscopical study is presented of the habits exhibited by chain-folded polyoxymethylene crystals grown from hot 0.02 percent solutions of the polymer in orthodichlorobenzene when these solutions are cooled to temperatures ( $T_c$ ) between 140 and 80 °C inclusive. In contrast with the lamellar crystals formed in the  $T_c = 140$  and 120 °C preparations, which crystals were six-sectored and nearly planar, the crystals formed below  $T_c = 120$  °C exhibited multisectored dendritic habits and were all the more pronouncedly curved the lower the temperature at which they grew. The most pronouncedly curved crystals which were observed were hollow bowl shaped dendrites having a radius of curvature of  $\sim 2\mu\text{m}$  which were formed in the 80 °C preparations. The possible origins of why the lamellar crystals of polyoxymethylene were all the more pronouncedly curved the lower the crystallization temperature are considered in the light of conjectures which have been previously advanced concerning the formation of curved crystals of poly(4-methylpentene-1). Among the features which are discussed is the role played by the bulkiness of the chain folds.

**Solid-phase behavior of several long-chain *n*-paraffins, esters, and a ketone**, P. K. Sullivan, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 2, 131-141 (Mar.-Apr. 1974).

Key words: dielectric loss; *n*-paraffins; phase transitions; x-ray scattering.

The long-spacings of the compounds methyl stearate, ethyl stearate, *n*-butyl stearate, 2-nonadecanone, *n*-eicosane, *n*-hexatriacontane and *n*-tetratetracontane have been examined as a function of temperature by means of low-angle x-ray diffraction. The intensity of the long-spacing was also determined versus temperature. The effect of annealing temperature and time was examined by means of the DSC. Dielectric loss was studied in two crystalline phases of *n*-butyl stearate.

**Simultaneous measurements of heat capacity, electrical resistivity, and hemispherical total emittance by a pulse heating technique: Vanadium, 1500 to 2100 K**, A. Cezairliyan, F. Righini, and J. L. McClure, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 2, 143-147 (Mar.-Apr. 1974).

Key words: electrical resistivity; emittance; heat capacity; high-speed measurements; high temperature; thermodynamics; thermophysics; vanadium.

Simultaneous measurements of heat capacity, electrical re-

sistivity, and hemispherical total emittance of vanadium in the temperature range 1500 to 2100 K by a subsecond duration, pulse heating technique are described. The results are expressed by the relations:

$$c_p = 56.34 - 3.839 \times 10^{-2} T + 1.563 \times 10^{-5} T^2$$

$$\rho = 8.794 + 6.282 \times 10^{-2} T - 6.804 \times 10^{-6} T^2$$

where  $c_p$  is in  $\text{J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$ ,  $\rho$  is in  $10^{-8} \Omega \cdot \text{m}$ , and  $T$  is in K. The values for the hemispherical total emittance are: 0.313 at 1900 K and 0.332 at 2000 K. Estimated inaccuracies of the measured properties are: 3 percent for heat capacity, 0.5 percent for electrical resistivity and 5 percent for hemispherical total emittance.

**The shape of idealized grain boundaries**, S. R. Coriell, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 2, 149-150 (Mar.-Apr. 1974).

Key words: boundary shape; curvature; grain boundary.

Mullins has treated a two-dimensional model of grain boundary motion in which each point on the boundary moves toward its center of curvature with a speed proportional to its curvature. For boundaries which preserve shape under uniform magnification, an integral representation of the boundary shape is found. We then obtain several analytic results from approximate evaluations of the integral.

**Reactions of fluorocarbon ions in  $\text{C}_2\text{F}_6$ . Implications for the radiolysis**, L. W. Sieck, R. Gorden, Jr., and P. Ausloos, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 2, 151-156 (Mar.-Apr. 1974).

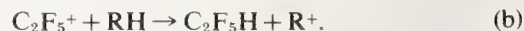
Key words: fluorocarbons; heats of formation; ion-molecule reactions; mass spectrometry; photoionization; rate constants.

Reactions of the fragment ions formed in the photoionization of  $\text{C}_2\text{F}_6$ ,  $\text{Xe}-\text{C}_2\text{F}_6$ , and  $\text{Kr}-\text{C}_2\text{F}_6$  mixtures have been investigated in the NBS photoionization mass spectrometer using both helium (21.2 eV) and neon (16.66-16.84 eV) resonance radiation. Contrary to previously held views, it is shown that  $\text{CF}_3^+$  ions having no internal excitation energy undergo the  $\text{F}^-$  transfer reaction:



A rate constant of  $4 \pm 1 \times 10^{-11} \text{ cm}^3/\text{molecule} \cdot \text{s}$  is determined for reaction (a) at pressures below  $10^{-2}$  torr. On the basis of the collision rate for these reactants, it can be estimated that, on the average, each  $\text{CF}_3^+$  ion undergoes 16 unreactive collisions before undergoing reaction (a). Therefore, from the facts that (1) in pure  $\text{C}_2\text{F}_6$ , all  $\text{CF}_3^+$  ions undergo reaction (a) at high pressures, and (2)  $\text{CF}_3^+$  ions formed by charge transfer from  $\text{Xe}^+$  ions with a maximum of 8.4 kJ/mol (2 kcal/mol) excess energy undergo reaction (a), one must conclude that reaction (a) is either thermoneutral or exothermic for ground state  $\text{CF}_3^+$  ions. Therefore, the earlier estimate for  $\Delta H_f(\text{C}_2\text{F}_5^+)$  of  $\sim 33$  kJ/mol (8 kcal/mol) must be revised downward:  $\Delta H_f(\text{C}_2\text{F}_5^+) \leq 3.8$  kJ/mol (0.9 kcal/mol).

The  $\text{C}_2\text{F}_5^+$  ion is unreactive towards  $\text{C}_2\text{F}_6$ , but does react with alkanes through the  $\text{H}^-$  transfer reaction:



It is suggested that the  $\text{CF}_4$  observed in previous gas and liquid phase radiolysis studies of  $\text{C}_2\text{F}_6-\text{O}_2$  mixtures can be entirely ascribed to reaction (a). Small concentrations of impurities or accumulated products will react with the  $\text{C}_2\text{F}_5^+$  ions under normal low dose rate radiolysis conditions.

**A simple technique for the generation of dilute mixtures of pollutant gases**, W. Tsang, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 2, 157-162 (Mar.-Apr. 1974).



Key words: acetaldehyde; acrolein; air pollution; calibration; decomposition; formaldehyde; reactive gases.

The pyrolysis of compounds whose decomposition produces equal numbers of reactive and stable molecules provides a simple quantitative means of generating dilute mixtures of formaldehyde, acetaldehyde and acrolein. The requirements with respect to the thermal stability of such "parent" compounds are discussed and the possible extensions to other reactive gas systems are considered.

**Energy levels and classified lines in the second spectrum of thorium (Th II),** R. Zalubas and C. H. Corliss, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 2, 163-246 (Mar.-Apr. 1974).

Key words: energy levels of Th II;  $g$ -values of Th II; spectrum of Th II; Th II spectrum; thorium; wavelengths of Th II.

The analysis of Th II has been extended with improved observations of the spectrum between 2000 and 25 000 Å. About 6500 lines are classified as transitions between 199 odd levels and 271 even levels. Of the 192 levels expected from the six odd configurations  $5f(6d+7s)^2$  and  $(6d+7s)^27p$ , 188 are now known. In the even level system, all but one of the 37 levels of the three  $(6d+7s)^3$  configurations are known. Of the 268 levels predicted for the configurations  $5f^27s+5f7s7p+5f6d7p+5f^26d$ , 235 are now known. The identifications are based on the theoretical calculations by N. Minsky. New Zeeman effect observations have increased the number of levels with known  $g$ -values to 406 out of 470 known levels. The classifications will be useful in establishing secondary standards of wavelength.

**Proposed secondary wavelength standards and line classifications in thorium spectra between 0.9 and 3  $\mu$ m,** A. Giacchetti, J. Blaise, C. H. Corliss, and R. Zalubas, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 2, 247-281 (Mar.-Apr. 1974).

Key words: classified lines of Th I and Th II; Fourier transform spectra of Th; infrared spectra of Th; spectra of Th; Th I and Th II; thorium spectra; wavelengths of Th.

The spectrum of thorium as emitted by an electrodeless lamp has been recorded by Connes and collaborators by means of Fourier Transform Spectroscopy in the region 0.9 to 3  $\mu$ m. Of the 3100 lines observed, about 1900 are classified as transitions in the energy level system of Th I and 412 in Th II. Since the average deviation between the observed and calculated wave numbers is less than  $0.002\text{ cm}^{-1}$ , the observed wavelengths are suitable for use as standard wavelengths.

## May-June 1974

**Photoionization of CO<sub>2</sub>-CO-O<sub>2</sub> mixtures. Formation and reactions of ion clusters,** L. W. Sieck and R. Gorden, Jr., *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 3, 315-322 (May-June 1974).

Key words: CO; CO<sub>2</sub>; ion-molecule reactions; O<sub>2</sub>; photoionization; radiolysis; rate constants.

Various mixtures containing combinations of CO<sub>2</sub>, O<sub>2</sub>, or CO have been photoionized at 16.7 and 21.2 eV at pressures up to 1.5 torr in the NBS high pressure photoionization mass spectrometer. In CO<sub>2</sub>-CO mixtures the interactions of CO<sub>2</sub><sup>+</sup> ions eventually lead to the formation of (CO)<sub>2</sub><sup>+</sup> and [(CO)<sub>2</sub>·CO<sub>2</sub>]<sup>+</sup> cluster ions, while photoionization of CO<sub>2</sub>-CO-O<sub>2</sub> mixtures yields mainly oxygen-containing clusters at higher pressures. The investigation of O<sub>2</sub>-CO mixtures also revealed reactions between O<sub>4</sub><sup>+</sup> and CO. The role of impurity reactions involving H<sub>2</sub>O is considered in some detail, and the implications of all of these data to the vapor phase radiolysis of CO<sub>2</sub> is discussed.

**Analysis of low temperature viscosity data for three NBS standard glasses,** A. Napolitano, J. H. Simmons, D. H. Blackburn, and R. E. Chidester, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 3, 323-329 (May-June 1974).

Key words: beam-bending; fiber-elongation; Fulcher equation; glass viscosity; standard reference material; viscosity; viscosity standard.

The low temperature viscosities of three glasses established as viscosity standards at the National Bureau of Standards are reported. The data overlap results which appear on the published certificates between  $10^9$  and  $10^{12}$  poise and present extensive measurements up to  $10^{16}$  poise. The measurements were made using both the fiber-elongation and beam-bending methods. No evidence of an Arrhenius behavior was found for any of the three glasses, even though the measurements covered a narrow range of temperatures. An analysis of the inherent measurement uncertainty associated with each method indicates that the fiber-elongation measurements are more precise than the beam-bending measurements. Analysis of the data and its uncertainty by the Fulcher Equation supports the conclusions of the error analysis.

**PVT relationships for liquid and glassy poly(vinyl acetate),** J. E. McKinney, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 3, 331-353 (May-June 1974).

Key words: density; dilatometer; entropy; glass transition; glass; liquid; polymer; poly(vinyl acetate); PVT; relaxation.

PVT measurements were made on liquid and glassy poly(vinyl acetate) over ranges of  $-30$  to  $100^\circ\text{C}$  and  $0$  to  $800$  bar (gage pressure). The data were obtained by three different thermodynamic histories: (a) variable formation pressure, (b) constant formation pressure at one atmosphere, and (c) constant formation pressure at  $800$  bar. In all of these the glass was formed by isobaric cooling at  $5^\circ\text{C/h}$ . The salient characteristics resulting from the different histories are the following. History (a) produces a glass of structure varying with formation pressure and, hence, does not necessarily give the proper thermodynamic properties of a "single physical substance." However, the liquid-glass intersection temperature,  $T_g(P)$ , is an important kinetic, or relaxational, property which approximates an isoviscous state. Accordingly, the values of  $dT_g/dP$  are in close agreement with those obtained from dynamic mechanical and dielectric time-temperature-pressure superposition. Constant formation histories (b) and (c) give proper thermodynamic properties of the glasses, but very little information with respect to kinetics. Increasing the pressure at which the glass is formed increases the density of the glass (at the given cooling rate) considerably in contrast to the entropy (from other work), which appears to be essentially independent of formation pressure.

A considerable part of the paper is definitional. The results are related to other PVT, dynamic mechanical, dielectric, and thermodynamic measurements. Interpretations are given in terms of both phenomenological and molecular models.

**Correction and extension of van der Poel's method for calculating the shear modulus of a particulate composite,** J. C. Smith, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 3, 355-361 (May-June 1974).

Key words: bulk modulus; composite materials; elastic constants; filled polymers; mechanical properties; particulate composites; shear modulus; theory of elasticity.

Van der Poel's method (Rheol. Acta 1, 198 (1958) for calculating the shear modulus of a particulate composite agrees well with experimental data, but its validity has been questioned, and it was applicable only to composites in which the matrix material is incompressible. These limitations are removed in this paper in which an error in the original derivation is corrected and the method generalized to apply to any matrix material. Calculations



using the corrected theory show that despite the error, a table of shear modulus values published with the original theory is sufficiently correct for most practical purposes. Applicability of the generalized method to the large class of composites having compressible matrices is discussed. Shear moduli calculated by the corrected and extended method are compared with corresponding values calculated by other methods currently used.

**The formation of curved polymer crystals: Polychlorotrifluoroethylene,** J. D. Barnes and F. Khoury, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 3, 363-373 (May-June 1974).

Key words: crystal morphology; crystallization; electron microscopy; optical microscopy; polychlorotrifluoroethylene; solution crystallization.

The habits and fine structure of crystals of polychlorotrifluoroethylene (PCTFE) grown from dilute solution were studied as functions of crystallization temperature. The solvent used was a low molecular weight PCTFE oil. The simplest crystals found were monolayered chain folded lamellae formed at 110 °C. These lamellae are planar and possess an unusual texture characterized by the presence of fine channel-like voids in the interior of the crystals. These lamellae do not exhibit well-formed crystal faces but are disc-like in overall shape. At lower crystallization temperatures the crystals take the form of complex arrays of curved lamellae which are aggregated into, among others, watchglass-shaped or hollow spherical objects. The variation of the curvature of the crystals with crystallization temperature is discussed in the light of previous studies of the formation of curved crystals of poly(4-methylpentene-1) and polyoxymethylene.

**Enthalpy of formation of phosphorus pentachloride; derivation of the enthalpy of formation of aqueous orthophosphoric acid,** R. H. Schumm, E. J. Prosen, and D. D. Wagman, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 3, 375-386 (May-June 1974).

Key words: enthalpy of formation; phosphoric acid; phosphorus pentachloride.

When chlorine (real gas, 980 mmHg) combines with white ( $\alpha$ ) phosphorus to form phosphorus pentachloride at 24.89 °C,  $3986 \pm 2.7$  J of heat are liberated per gram of stoichiometrically equivalent  $\text{Mg}_2\text{P}_2\text{O}_7$ . This value was determined by a dead-ended flow system in an electrically calibrated isoperibol calorimeter. Correction was made for the formation of up to one mol percent  $\text{PCl}_3$  in the products; no other impurities were found. From this value, the standard (25 °C, ideal gas) enthalpy of formation of  $\text{PCl}_5(\text{c})$  is calculated to be  $-443.85 \pm 0.30$  kJ/mol,  $-106.08 \pm 0.07$  kcal/mol. When this figure is combined with a recent determination of the enthalpy of hydrolysis of  $\text{PCl}_5(\text{c})$ , the standard enthalpy of formation of  $\text{H}_3\text{PO}_4(\text{aq}, 100 \text{ H}_2\text{O})$  is calculated to be  $-1296.5 \pm 1.5$  kJ/mol, in good agreement with two other values which involve the formation and hydrolysis of  $\text{P}_4\text{O}_{10}(\text{hex})$ . A "best value" is suggested:  $\Delta H_f^\circ(\text{H}_3\text{PO}_4, 100 \text{ H}_2\text{O}) = -1295.8 \pm 1.3$  kJ/mol,  $-309.7 \pm 0.3$  kcal/mol.

**Heat capacities of polyethylene from 2 to 360 K. II. Two high density linear polyethylene samples and thermodynamic properties of crystalline linear polyethylene,** S. S. Chang, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 3, 387-400 (May-June 1974).

Key words: amorphous polyethylene; calorimetry; crystalline polyethylene; extended chain crystals; glass transition temperature; heat capacity; linear polyethylene; polyethylene; thermodynamic properties.

Heat capacities of two high density linear polyethylene samples were measured from 2 to 360 K. By incorporating the results from the previous work of this series, thermodynamic

properties of completely crystalline linear polyethylene may be estimated.  $C_p$ ,  $H - H_0$ ,  $S$  and  $-(G - H_0)$  at 298.15 K for crystalline linear polyethylene are estimated to be 22.60 J K<sup>-1</sup> mol<sup>-1</sup>, 3544 J mol<sup>-1</sup>, 23.02 J K<sup>-1</sup> mol<sup>-1</sup> and 3319 J mol<sup>-1</sup>, respectively. Spontaneous adiabatic temperature drifts were observed in both samples near 240 K. These drifts may be attributed to the enthalpy relaxation phenomena occurring in the glass transformation region.

**The specific heats,  $C_p$ , and  $C_v$ , of compressed and liquefied methane,** B. A. Younglove, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 3, 401-410 (May-June 1974).

Key words: constant volume; heat capacity; liquid; saturated liquid; specific heat; methane.

The specific heats,  $C_p$ , of saturated liquid methane have been measured at 66 temperatures in the temperature range 95-187 K. The specific heats at constant volume,  $C_v$  have been measured at 20 densities ranging from 0.8 to 2.8 times the critical density, at temperatures between 91 and 300 K, and at pressures to 330 bar (at 280 *PVT* states in all). The uncertainty of most of the measurements is estimated to be less than 0.5 percent, except near the critical point. These measurements were performed primarily to provide input data for accurate thermodynamic properties data calculations for liquid methane. They are believed to be the most comprehensive specific heat measurements available for pure compressed gaseous and liquid methane.

**An improved procedure for synthesis of DL-4-hydroxy-3-methoxymandelic acid (DL-"vanillyl"-mandelic acid, VMA),** A. J. Fatiadi and R. Schaffer, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 3, 411-412 (May-June 1974).

Key words: alkaline condensation; glyoxylic acid; quaiacol; synthesis; vanillyl-mandelic acid; VMA.

An improved procedure for synthesis of DL-4-hydroxy-3-methoxymandelic acid (DL-vanillyl-mandelic acid, VMA) entails slow addition of an ice-cold, aqueous solution of glyoxylic acid to an ice-cold alkaline solution of guaiacol, with efficient mechanical stirring. This one-step condensation procedure provides VMA in 68-75 percent yield.

**Single particle motions in liquids: Qualitative features of memory functions,** R. D. Mountain, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 3, 413-420 (May-June 1974).

Key words: depolarized Rayleigh scattering; ideal gas; incoherent neutron scattering; infrared absorption; liquid state; memory function; projection operator; Raman scattering; time correlation function.

Memory functions, which enter into the equations of motion for time correlation functions, are constructed from neutron scattering, infrared absorption and light scattering data involving single particle motions in liquids. The qualitative features of these memory functions are related to the shape of the corresponding time correlation functions. It is found that a negative portion to the memory function is indicative of a rapid loss of correlation in time while strong temporal correlations imply a memory function which does not go negative. The mathematical structure of a memory function is examined for the case of the ideal gas by expanding and evaluating the projection operator representation of the function. The resulting expression has a rich mathematical structure and can be expressed in a closed form only for its Laplace transform.

**The infrared spectra of matrix isolated uranium oxide species,** S. Abramowitz and N. Acquista, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 3, 421-424 (May-June 1974).

Key words: infrared spectra; mass spectrophotometry; matrix isolated; oxides of uranium.



The infrared spectra of matrix isolated products of the interaction of uranium and oxygen have been investigated at high temperatures. By use of collateral available data on the various uranium oxide species, plus employment of oxygen 16 and 18 isotopes, peak assignments were verified for many of the neutral metal oxide species.

## July-August 1974

**The glass transition temperature of monodispersed polystyrenes and their binary mixtures**, L. A. Wall, Roestamsjah, and M. H. Aldridge, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 4, 447-451 (July-Aug. 1974).

Key words: binary mixtures; glass transition temperature; monodispersed polystyrene.

Glass transition measurements on monodispersed polystyrenes of different molecular weight and their binary mixtures result in the following conclusions: (a) the effect of molecular weight on the glass transitions of monodispersed samples satisfies the Fox and Flory equation written as  $T_g = T_{g\infty} - A/M_n$ , with constant  $A = 0.84 \times 10^{-5}$ ; (b) polymers of the same number average molecular weight with a broad distribution show lower glass transitions than the monodisperse; (c) the binary mixtures follow the Gordon-Taylor equation derived for copolymers, with constant  $k$  (experimental) 0.5.

**A method of measuring the solubilities of hydrocarbons in aqueous solutions**, R. L. Brown and S. P. Wasik, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 4, 453-460 (July-Aug. 1974).

Key words: aqueous solutions; benzene solubility; hydrocarbons; partition coefficients; seawater.

An apparatus is described which measures the equilibrium distribution of a hydrocarbon between a gas phase and a liquid water phase. The method involves a multiple equilibration procedure which requires the analysis of only the gas phase. Gas-liquid chromatography was used for the hydrocarbon analysis because of its high sensitivity and selectivity. Supplemented by vapor pressure data, the observed distribution can be used to calculate the solubility of the hydrocarbon in the liquid phase. This was done for benzene, toluene, and ethylbenzene in distilled water over the temperature range 5 to 20 °C and in an artificial seawater over the temperature range 0 to 20 °C. The various factors affecting the accuracy of the results are discussed in detail.

**Theoretical and experimental Compton scattering cross sections at 1.12 MeV in the case of strongly bound K-shell electrons**, P. N. Baba Prasad and P. P. Kane, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 4, 461-463 (July-Aug. 1974).

Key words: Compton scattering; differential cross section; electron binding; gamma rays; K-shell; photons.

Measurements are reported for the differential cross sections for Compton scattering of 1.12 MeV gamma rays by the K-shell electrons of tin, tantalum, gold, and thorium. A few discrepancies between approximate theoretical calculations and the experimental results for different energies are pointed out. The need for an exact relativistic calculation is indicated.

**Standardization of  $^{60}\text{Co}$  and  $^{137}\text{Cs}$  gamma-ray beams in terms of exposure**, T. P. Loftus and J. T. Weaver, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 4, 465-476 (July-Aug. 1974).

Key words: cavity ionization chamber; exposure; gamma rays;  $^{60}\text{Co}$ ;  $^{137}\text{Cs}$ ; standards.

At the National Bureau of Standards (NBS), the exposure-rate standards for  $^{60}\text{Co}$  and  $^{137}\text{Cs}$  gamma rays were based for a

number of years on a weighted average of measurements using a cylindrical ionization chamber and a group of small spherical chambers. Complex setup conditions for the cylindrical chamber, differences between the cylindrical and spherical chamber data, and recognition that the institution of this weighted average exposure-rate standard increased the difference between free-air-chamber and cavity-chamber measurements, led to the development of new spherical chambers. All correction factors for exposure-rate measurements were investigated and updated. Excellent agreement was achieved between independent exposure-rate measurements for six spherical chambers and, as of May 1, 1972, the exposure standards were reduced 0.7 percent for  $^{60}\text{Co}$  and 0.6 percent for  $^{137}\text{Cs}$  gamma rays. Recalculation of correction factors since that time indicates that the standard  $^{137}\text{Cs}$  should be further reduced by 0.2 percent, and this adjustment was made on July 1, 1974.

The uncertainties associated with each of the quantities entering into the determination of exposure rate were tabulated and the overall uncertainty of the exposure rates used for instrument calibrations at NBS was found to be about 0.7 percent for addition in quadrature.

**Investigation of freezing temperatures of National Bureau of Standards aluminum standards**, G. T. Furukawa, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 4, 477-495 (July-Aug. 1974).

Key words: A-C bridge; aluminum; aluminum point; fixed point; freezing point; IPTS-68; platinum resistance thermometer.

The design of a high-precision furnace for investigating the freezing points of metals up to 700 °C or higher is described. The freezing points of aluminum samples of nominally 99.999 percent purity from two batches were compared in terms of the ratio  $R(\text{Al})/R(\text{TP})$ , the ratio of the resistance of the platinum resistance thermometer at the aluminum freezing point to that at the triple point of water. The average standard deviation of measurements of the ratio  $R(\text{Al})/R(\text{TP})$  obtained on six specimens corresponds to  $\pm 0.40$  mK, while the average standard deviations of  $R(\text{Al})$  and  $R(\text{TP})$  correspond to  $\pm 0.17$  mK and  $\pm 0.14$  mK, respectively. (The variations in the measurements of  $R(\text{TP})$  are amplified by 3.4 in the ratio  $R(\text{Al})/R(\text{TP})$ .) The spread of the mean  $R(\text{Al})/R(\text{TP})$  obtained for five out of the six specimens corresponds to 0.51 mK; the deviation of the mean  $R(\text{Al})/R(\text{TP})$  of the sixth specimen from the mean  $R(\text{Al})/R(\text{TP})$  of the five specimens corresponds to  $-1.31$  mK. (The sixth specimen may have been contaminated during the assembly of the freezing-point cell or the original sample bar was inhomogeneous.) The results show that aluminum can provide a freezing point (near 660 °C) that is at least as reproducible as the freezing point of antimony (near 631 °C).

**Prediction of the viscosities of "soda-lime" silica glasses**, K. C. Lyon, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 4, 497-504 (July-Aug. 1974).

Key words: composition; Fulcher equation; glasses; soda-lime glasses; viscosity.

Published data are used to develop factors for predicting the viscosity-temperature relationship from the compositions of "soda-lime" type silicate glasses at specific temperatures in the range of 600 to 1300 °C. The effects of  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$ ,  $\text{CaO}$ ,  $\text{MgO}$ ,  $\text{Al}_2\text{O}_3$  and their interactions are evaluated. The influence of minor amounts of  $\text{BaO}$ ,  $\text{B}_2\text{O}_3$ ,  $\text{Li}_2\text{O}$ , and  $\text{F}_2$ , in the temperature range of 700 to 1300 °C, is estimated.

**The system  $\text{NaCl-AlCl}_3$** , E. M. Levin, J. F. Kinney, R. D. Wells, and J. T. Benedict, *J. Res. Nat. Bur. Stand. (U.S.)*, 78A (Phys. and Chem.), No. 4, 505-507 (July-Aug. 1974).



Key words: immiscibility;  $\text{NaAlCl}_4$ ; phase equilibrium; system  $\text{AlCl}_3\text{-NaCl}$ ; system  $\text{NaCl-AlCl}_3$ .

The system  $\text{NaCl-AlCl}_3$  has been restudied by DTA, visual observation, and x-ray diffraction powder techniques for identification of crystalline phases. It was confirmed that the system contains one intermediate compound  $\text{NaAlCl}_4$  with an incongruent mp of  $153 \pm 0.5^\circ\text{C}$  and a region of liquid immiscibility extending from 80.25 to 99.6 mol percent  $\text{AlCl}_3$  at  $191.3^\circ\text{C}$ , the monotectic temperature.

**Simultaneous measurements of heat capacity, electrical resistivity and hemispherical total emittance by a pulse heating technique: zirconium, 1500 to 2100 K,** A. Cezairliyan and F. Righini, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 4, 509-514 (July-Aug. 1974).

Key words: electrical resistivity; emittance; heat capacity; high-speed measurements; high temperature; thermodynamics; thermophysical properties; zirconium.

Simultaneous measurements of heat capacity, electrical resistivity and hemispherical total emittance of zirconium in the temperature range 1500 to 2100 K by a subsecond duration, pulse heating technique are described. The results are expressed by the relations:

$$C_p = 36.65 - 1.435 \times 10^{-2} T + 6.624 \times 10^{-6} T^2$$

$$\rho = 87.95 + 1.946 \times 10^{-2} T$$

$$\epsilon = 0.2031 + 6.362 \times 10^{-5} T$$

where  $C_p$  is in  $\text{J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$ ,  $\rho$  is in  $10^{-8} \Omega\cdot\text{m}$ , and  $T$  is in K. Estimated inaccuracies of the measured properties are: 3 percent for heat capacity, 2 percent for electrical resistivity and 5 percent for hemispherical total emittance.

**Measured enthalpy and derived thermodynamic properties of crystalline and liquid potassium chloride, KCl, from 273 to 1174 K,** T. B. Douglas and A. W. Harman, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 4, 515-529 (July-Aug. 1974).

Key words: heat of fusion; high-temperature drop calorimetry; lattice vacancies; muriate of potash; potassium chloride; sylvite; thermodynamic properties.

The enthalpy of KCl relative to that at 273.15 K was precisely measured by drop calorimetry from 273 to 1174 K, and smooth thermodynamic functions were derived for this temperature range. The heat capacities found for the crystalline phase join smoothly the most precise published data for lower temperatures; those for the liquid phase are temperature-independent within the precision of measurement over the  $120^\circ$  range covered. It is concluded that the broad exponential upturn of the heat-capacity curve below the melting point, if attributed to lattice vacancies, indicates a predominance of large vacancy clusters.

## September-October 1974

**Spectrum of doubly ionized praseodymium from 2107 Å to 10716 Å,** J. Sugar, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 5, 555-593 (Sept.-Oct. 1974).

Key words: line classifications; praseodymium; Pr III; spectrum.

Wavelengths, relative intensity estimates, and classifications of the spectral lines of doubly ionized praseodymium (Pr III) in the range of 2107 to 10716 Å are given. About 4400 lines are included of which some 2500 are classified.

**A heat-loss-compensated calorimeter: Theory, design, and performance,** S. R. Domen and P. J. Lamperti, *J. Res. Nat. Bur.*

*Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 5, 595-610 (Sept.-Oct. 1974).

Key words: absorbed dose; calorimeter; heat-loss-compensation; thermal gradients.

A new type of 3-body calorimeter for measuring absorbed dose produced by ionizing radiation is described in detail. All three bodies rise in temperature during irradiation, and the heat absorbed by the central core is measured by standard means. Only the central core is heated during electrical calibration, but the increased heat losses are compensated by measuring most of the heat lost to the surrounding jacket and automatically adding it to the heat retained by the core. The third body is a massive, thermally-floating shield, whose presence reduces the heat losses during irradiation, with a consequent increase in sensitivity and stability. A mathematical description of the calorimeter behavior is presented, along with a discussion of control and operation technique. In particular it is shown how this 3-body calorimeter can be calibrated as a 1-body calorimeter, with large heat losses, or as a 2-body calorimeter, in the quasi-adiabatic mode. This calorimeter design decreases the effects of thermal gradients and at the same time provides the means to test for these effects. The results of these tests show that for this particular model, systematic errors caused by thermal gradients, during electrical measurements, are no larger than 0.1 percent. Errors in comparing an electrical run with an irradiation may be somewhat larger because of different temperature gradient within the system. It is also pointed out that the general design of this calorimeter is not restricted to measuring absorbed dose but can be applied to calorimetry in general.

**The enthalpies of combustion and formation of linear polyethylene,** P. L. Splitstone and W. H. Johnson, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 5, 611-616 (Sept.-Oct. 1974).

Key words: enthalpy; heat of combustion; heat of crystallization; heat of formation; polymer; standard reference polymer.

The enthalpies of combustion and formation of two samples of linear polyethylene which differ only in the degree of crystallinity have been determined in an oxygen bomb calorimeter. For the two samples the degree of crystallinity, the enthalpy of combustion at 298.15 K, and the enthalpy of formation at 298.15 K, were respectively: 72 percent,  $-651.16 \pm 0.12 \text{ kJ}\cdot\text{mol}^{-1}$ ,  $-28.18 \pm 0.13 \text{ kJ}\cdot\text{mol}^{-1}$  for the less crystalline sample; and 96 percent,  $-650.27 \pm 0.12 \text{ kJ}\cdot\text{mol}^{-1}$  and  $-29.08 \pm 0.12 \text{ kJ}\cdot\text{mol}^{-1}$  for the more crystalline sample. The values are per mole of  $\text{CH}_2$ . Uncertainties listed are estimates of accuracy of approximate 95 percent confidence limits. The results of previous determinations by other investigators are discussed briefly.

**High pressure measurements of density, velocity of sound, and bulk moduli of pentane and 2-methylbutane and their mixtures,** J. C. Houck, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 5, 617-622 (Sept.-Oct. 1974).

Key words: bulk modulus; compressibility; density; dilatometric measurements; high pressure; liquids; 2-methylbutane; pentane; ultrasonics.

Dilatometric and ultrasonic measurements were made on mixtures of pentane and 2-methylbutane to give density, relative volume, isothermal bulk modulus, velocity of sound, and adiabatic bulk modulus to pressure of 24 kilobars ( $2.4 \times 10^9 \text{ N/m}^2$ ).

**Long-time creep in a pure-gum rubber vulcanizate: Influence of humidity and atmospheric oxygen,** L. A. Wood, G. W. Bullman, and F. L. Roth, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 5, 623-629 (Sept.-Oct. 1974).



**Key words:** compliance of rubber; creep, long-time, in rubber; humidity, effect of, on creep of rubber; modulus of rubber, effect of humidity; oxygen, influence of, on creep of rubber; rubber, natural, creep; time, effect of, on compliance of rubber.

Long-time creep of natural rubber cured with a sulfur-accelerator recipe containing no filler can be conveniently represented by a plot of  $(E - E_1)/E_1 = \Delta E/E_1$  with a double-abscissa scale showing  $\log t$  and  $t$ .  $E$  is the elongation at any time  $t$ , after application of the load, and  $E_1$  its value at unit time. Experimental data conform to the equation

$$\Delta E/E_1 = A \log t + B(t - 1)$$

except for a more rapid rise preceding rupture. The constants  $A$  and  $B$  can be evaluated from only three observations — at the longest time (about 70 days), at one minute, and at an intermediate time.  $\Delta E/E_1$  is approximately linear with  $\log t$  when  $t$  is less than  $0.1(A/B)$  and approximately linear with  $t$  when  $t$  is greater than  $4.343(A/B)$ . The observed modulus was about 1.4 MPa and  $A$  was about 2.4 percent/(unit  $\log t$ ) when the atmosphere was a vacuum, dry  $N_2$ , or dry air. The modulus was lowered very slightly and  $A$  became about 4 percent/(unit  $\log t$ ) when the air was saturated with water.  $B$  was raised from about  $2 \times 10^{-5}$  percent/min to about  $20 \times 10^{-5}$  percent/min when the vacuum or dry  $N_2$  was replaced by dry air and to about  $50 \times 10^{-5}$  percent/min when the air was saturated with moisture.  $A$  is considered to be related to physical relaxation, while  $B$  corresponds to a chemical reaction, probably oxidative degradation.

**Adaptation of a high-accuracy spectrophotometer for ultraviolet work**, K. D. Mielenz, R. Mavrodineanu, and E. D. Cehelnik, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 5, 631-636 (Sept.-Oct. 1974).

**Key words:** averaging sphere; deuterium arc lamp; fluorescent wavelength converter; grating; spectrophotometry; standard reference materials; ultraviolet; UV achromats; visible.

A high-accuracy spectrophotometer, originally designed for work at visible wavelengths, was modified to permit measurements in the ultraviolet without degradation of its original performance. This was accomplished by equipping the spectrophotometer with a stable deuterium arc source, a highly efficient averaging sphere with fluorescent wavelength converter, a new grating, and achromatic sample-compartment optics. The modified spectrophotometer will be used for the development of new Standard Reference Materials, as well as for materials research, in the region between 200 and 300 nm.

## November-December 1974

**Solubility of  $\beta$ - $Ca_3(PO_4)_2$  in the system  $Ca(OH)_2$ - $H_3PO_4$ - $H_2O$  at 5, 15, 25, and 37 °C**, T. M. Gregory, E. C. Moreno, J. M. Patel, and W. E. Brown, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 6, 667-674 (Nov.-Dec. 1974).

**Key words:** beta-tricalcium phosphate, preparation; solubility, solubility product, stoichiometry of; dissolution, thermodynamics of; ion pairs; singular points; solubility isotherms; thermal coefficient of solubility.

Solubility isotherms of beta-tricalcium phosphate,  $\beta$ - $Ca_3(PO_4)_2$ , prepared by heating mixtures of  $CaCO_3$  and  $CaHPO_4$  above 800 °C, were determined in the ternary system  $Ca(OH)_2$ - $H_3PO_4$ - $H_2O$  at 5, 15, 25, and 37 °C in the pH range 6.0-7.5 by

equilibration with dilute  $H_3PO_4$  solutions. The results indicate that  $\beta$ - $Ca_3(PO_4)_2$  has a negative thermal coefficient of solubility. The solubility product,  $K_s$ , was determined as a function of temperature by a generalized least-squares procedure; the resulting equation is

$$\log K_s = -45723.26/T + 287.4536 - 0.546763T;$$

the values of  $K_s$  and its dispersion at 25 and 37 °C are  $1.20(0.056)$ , and  $0.283(0.011) \times 10^{-29}$ . Thermodynamic functions for the dissolution of the salt at the four experimental temperatures are reported.

When treated as an adjustable constant, the Ca/P ratio in these  $\beta$ - $Ca_3(PO_4)_2$  solutions was found to have the value  $1.514(0.010)$ , confirming that the stoichiometry of the high temperature form of this salt is correctly indicated by the above formula.

**Solubility of  $CaHPO_4 \cdot 2H_2O$  in the quaternary system  $Ca(OH)_2$  -  $H_3PO_4$  -  $NaCl$  -  $H_2O$  at 25 °C**, P. R. Patel, T. M. Gregory, and W. E. Brown, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 6, 675-681 (Nov.-Dec. 1974).

**Key words:** brushite;  $CaHPO_4 \cdot 2H_2O$ ;  $NaHPO_4^-$  ion pair; solubility product; system  $Ca(OH)_2$  -  $H_3PO_4$  -  $H_2O$  -  $NaCl$ .

Solubility of  $CaHPO_4 \cdot 2H_2O$  was determined in the quaternary system  $Ca(OH)_2$  -  $H_3PO_4$  -  $NaCl$  -  $H_2O$  at 25 °C in the pH range 4.39-6.38; ionic strengths of the saturated solutions varied from 0.00485 to 0.545. Satisfactory constancy in the solubility product,  $(K_{sp} = [Ca^{2+}] \cdot [HPO_4^{2-}] \cdot \gamma_{Ca^{2+}} \cdot \gamma_{HPO_4^{2-}} = 2.49 \pm 0.05 \times 10^{-7} \text{ mol}^2 - 1^{-2})$  was obtained when (i) the ion activity coefficients,  $\gamma_i$ , were calculated with the Debye-Höckel equation,  $\log \gamma_i = -AZ_i^2 \sqrt{I}/(1 + B\alpha_i \sqrt{I}) + 0.0626I$  and the value 0.0626 for the coefficient in the linear term was derived from the solubility data by utilizing a statistical procedure, and (ii) formation of an ion pair  $NaHPO_4^-$  was taken into account; a statistically derived value for the stability constant of this ion pair is  $7.0 \pm 2.41 - \text{mol}^{-1}$ . The ion pair  $NaHPO_4^-$  appears to have significant concentrations in physiological fluids.

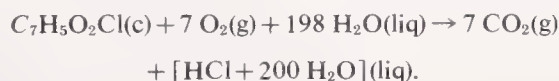
**The enthalpies of combustion and formation of the monochlorobenzoic acids**, W. H. Johnson and E. J. Prosen, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 6, 683-689 (Nov.-Dec. 1974).

**Key words:** combustion; enthalpy; formation; heat; isomerization; secondary standard.

The enthalpies of combustion of *o*-, *m*-, and *p*-chlorobenzoic acid have been determined in an adiabatic rotating-bomb calorimeter. The enthalpies of formation have been obtained by combination of the experimental data with the accepted values for the enthalpies of formation of water and for the formation and solution of hydrochloric acid. The results of other investigators are discussed briefly. The resulting values and their estimated 95 percent confidence limits are as follows:

|                              | $\Delta H_c^\circ$ (25 °C)<br>kJ/mol | $\Delta H_f^\circ$ (25 °C)<br>kJ/mol |
|------------------------------|--------------------------------------|--------------------------------------|
| <i>o</i> -Chlorobenzoic Acid | $-3087.67 \pm 0.69$                  | $-404.83 \pm 0.74$                   |
| <i>m</i> -Chlorobenzoic Acid | $-3067.91 \pm 1.53$                  | $-424.59 \pm 1.55$                   |
| <i>p</i> -Chlorobenzoic Acid | $-3064.34 \pm 0.66$                  | $-428.16 \pm 0.72$                   |

Where  $\Delta H_c^\circ$  corresponds to the process:





## 3.2. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION B. MATHEMATICAL SCIENCES, VOLUME 78B, JANUARY-DECEMBER 1974

### January-March 1974

**A class of positive stable matrices**, D. Carlson, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 1, 1-2 (Jan.-Mar. 1974).

Key words: positive stable matrix; sign-symmetry; spectrum.

A square complex matrix is positive sign-symmetric if all its principal minors are positive, and all products of symmetrically-placed minors are nonnegative. It is proved that every positive sign-symmetric matrix is positive stable.

**The Smith normal form of a partitioned matrix**, M. Newman, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 1, 3-6 (Jan.-Mar. 1974).

Key words: elementary divisors; invariant factors; partitioned matrices; Smith normal form.

It is shown that if

$$M = \begin{bmatrix} M_{11} & M_{12} & \dots & M_{1t} \\ 0 & M_{22} & \dots & M_{2t} \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & M_{tt} \end{bmatrix}$$

is a matrix over a principal ideal ring  $R$  such that the matrices  $M_{ii}$  are square and have pairwise relatively prime determinants, then the Smith normal form of  $M$  is the same as the Smith normal form of

$$M_{11} + M_{22} + \dots + M_{tt}.$$

**A Lyapunov theorem for angular cones**, C. R. Johnson, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 1, 7-10 (Jan.-Mar. 1974).

Key words: cramped; field of values; open positive convex cone; polar decomposition; positive definite; spectrum; square matrix.

The well known theorem of Lyapunov is generalized to characterize matrices whose spectra lie in a given open convex angular sector. Related facts about positive definite matrices, the polar decomposition and matrices with cramped spectra are also given.

**Second, third, and fourth order  $D$ -stability**, C. R. Johnson, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 1, 11-13 (Jan.-Mar. 1974).

Key words:  $D$ -stable; positive stable matrix; spectrum.

For  $n=2, 3$ , and  $4$ , conditions are given for the real  $n$  by  $n$   $D$ -stable matrices. The 3 by 3 sufficient condition is easily checkable and reveals to be  $D$ -stable a class of matrices which is not included in any known, general sufficient condition.

**Comparison of some FORTRAN programs for matrix inversion**, K. E. Fitzgerald, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 1, 15-33 (Jan.-Mar. 1974).

Key words: error estimates; evaluation of computer programs; execution time; inverse of a matrix; iterative refinement; linear systems.

In this paper several programs for computing the inverse of a matrix are compared primarily on the basis of execution time. Accuracy estimates and two programs that use iterative refinement are included. It is shown that for small matrices, improvement procedures are worthwhile but for large matrices, one must be more careful in their use. Two other points are also brought out: the value of multiplying matrices before taking the norm of a product and the need for some kind of an error estimate to be included in the output of every program.

**On characters of subgroups**, R. Merris, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 1, 35-38 (Jan.-Mar. 1974).

Key words: Frobenius Reciprocity Theorem.

Let  $H$  be a subgroup of  $G$ . Let  $\chi$  be an irreducible character of  $H$ . Let  $\chi^G$  be the character of  $G$  induced by  $\chi$ . The irreducibility of  $\chi^G$  is discussed. In particular, if  $H$  is normal in  $G$ , then  $\chi^G$  is irreducible if and only if  $\chi$  cannot be extended to any subgroup of  $G$  which properly contains  $H$ .

These results have application to the determination of irreducibility of a class of representations of the full linear groups.

**Integer arithmetic determination of polynomial real roots**, G. W. Reitwiesner, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 1, 39-43 (Jan.-Mar. 1974).

Key words: Budan theorem; exact computation; integer arithmetic; modular arithmetic; polynomial; polynomial real roots; roots; Sturm theorem.

The real roots of a polynomial with rational coefficients may be evaluated to absolute precision by integer arithmetic. Based upon the theorems of Sturm and Budan, two algorithms for this evaluation are described, and some comparative observations are offered.

### April-June 1974

**Rational equivalence of unimodular circulants**, S. Pierce, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 2, 63 (Apr.-June 1974).

Key words: circulant, totally positive unit.

We answer a question of M. Newman by providing all unimodular positive circulants are rationally equivalent to the identity.

**How to determine the accuracy of the output of a matrix inversion program**, M. Newman, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 2, 65-68 (Apr.-June 1974).

Key words: approximate inverses; approximate solutions; error bounds; high speed digital computation; matrix norms.

If  $A$  is a given nonsingular matrix and  $X$  an approximate inverse of  $A$  such that  $N(R) < 1$ , where  $R = I - AX$  and  $N$  is any matrix norm, then it is shown that

$$\frac{N(XR)}{1+N(R)} \leq N(A^{-1} - X) \leq \frac{N(XR)}{1-N(R)}.$$

This inequality provides the means for checking the output of a matrix inversion program. Methods for checking the solution of a single linear system are also discussed.

**A conjecture on a matrix group with two generators**, M. Newman, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 2, 69-70 (Apr.-June 1974).

Key words: free groups; matrix groups; roots of unity.

Let  $\zeta$  be a primitive  $q$ th root of unity. It is conjectured that the group generated by

$$A = \begin{pmatrix} 1 & \zeta \\ 0 & 1 \end{pmatrix} \quad \text{and} \quad B = \begin{pmatrix} 1 & 0 \\ \zeta & 1 \end{pmatrix}$$

is never free. The conjecture is proved when  $q$  is an even prime power, or an odd prime power having 2 as a primitive root.

**A property of equivalence**, M. Newman, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 2, 71-72 (Apr.-June 1974).

Key words: elementary divisors; equivalence; Kronecker products.

It is shown that if  $K, A, B$  are nonsingular matrices over a principal ideal ring  $R$  such that  $K \otimes A$  is equivalent to  $K \otimes B$ , then  $A$  is equivalent to  $B$ .

**Comments on the discrete matrix model of population dynamics**, R. Freese and C. R. Johnson, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 2, 73-78 (Apr.-June 1974).

Key words: eigenvalue; net reproduction rate; oscillations; Perron-Frobenius theory; rate of natural increase; stable population.

This paper examines several aspects of the discrete matrix model of population transition. Certain appropriate applications of matrix theory and exploitation of the specific form of the model should serve to enhance its already well-developed status. The aspects dealt with include (1) a simplification of the Perron-Frobenius theory; (2) row and column sum bounds on maximal eigenvalues; (3) relations between oscillations in a population and the remaining eigenvalues; (4) implications of stability for the transition matrix; and (5) relations between characteristic quantities of a stable population.

**Fixed-point solution of plant input/location problems**, A. J. Goldman, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 2, 79-94 (Apr.-June 1974).

Key words: CES; economics; Leontief; location theory; plant location; production functions; transportation; Weber problem, mathematical programming.

This paper considers the following generalization of the Weber plant location problem: the plant's output level is fixed, and its levels of input from its supply points, as well as its location, are among the decision variables. Hurter and Wendell (*J. Reg. Sci.*, 1972) showed that this problem admits a kind of separability when the plant's production function lies in a certain class including the Cobb-Douglas forms. The present paper (a) determines the extent of that function-class, (b) carries out the explicit separation for the CES generalization of the Cobb-Douglas functions, and (c) discusses simple fixed-point-type iterative solution algorithms, similar to that well-known for the ordinary Weber problem, for several production functions (Cobb-Douglas, CES, and various two-stage technologies). Local convergence of these algorithms is established; computational experience will be reported in a separate Part II.

**A new proof of Pick's theorem**, S. Minsker, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 2, 95-96 (Apr.-June 1974).

Key words: Bieberbach's theorem; coefficient estimate; univalent analytic function.

Pick's theorem states that, if  $f$  is a univalent analytic function

on the open unit disk with  $f(0) = 0$  and  $f'(0) = 1$ , and  $|f| \leq M$ , then  $\left| \frac{f''(0)}{2} \right| \leq 2 \left( 1 - \frac{1}{M} \right)$ . A new proof of this result is given, and a comparison with the usual proof is made.

## July-September 1974

**A sufficient condition for matrix stability**, C. R. Johnson, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 3, 103-104 (July-Sept. 1974).

Key words:  $M$ -matrix; principal minors; stable matrix.

An  $n$  by  $n$  complex matrix  $A$  is said to be positive stable if  $\operatorname{Re}(\lambda) > 0$  for each eigenvalue  $\lambda$  of  $A$ . If  $A$  satisfies both of the following two conditions, then  $A$  is positive stable: (1) for each  $k = 1, \dots, n$ , the real part of the sum of the  $k$  by  $k$  principal minors of  $A$  is positive; and (2) the minimum of the real parts of the eigenvalues of  $A$  is itself an eigenvalue of  $A$ . Special cases include hermitian positive definite matrices and  $M$ -matrices.

**Computation of the field of values of a  $2 \times 2$  matrix**, C. R. Johnson, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 3, 105-107 (July-Sept. 1974).

Key words: eigenvalues; ellipse; field of values; square matrix.

It is known that the field of values,  $F(A) \equiv \{x^*Ax : x^*x = 1, x \in \mathbb{C}^2\}$ , of a  $2 \times 2$  matrix  $A$  is a convex set whose boundary is an ellipse. This is used to compute  $F(A)$  explicitly from the entries of  $A$  when  $A$  is  $2 \times 2$  and real. Employing known properties of the field of values, this may then be used to estimate  $F(A)$  when  $A$  is  $n \times n$  and real.

**The factorization of a matrix as the commutator of two matrices**, J. M. Smith, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 3, 109-112 (July-Sept. 1974).

Key words: anticommuting; commutator; factorization; matrix; orthogonal; skew-symmetric.

Let  $P = I_p + (-I_q)$ , the direct sum of the  $p \times p$  identity matrix and the negative of the  $q \times q$  identity matrix. The following theorem is proved.

**THEOREM:** If  $X = cZ$  where  $Z$  is a  $4 \times 4$   $P$ -orthogonal,  $P$ -skew-symmetric matrix and  $|c| \leq 2$ , there exist matrices  $A$  and  $B$ , both of which are  $P$ -orthogonal and  $P$ -skew-symmetric, such that  $X = AB - BA$ . Methods for obtaining certain matrices which satisfy  $X = AB - BA$  are given. Methods are also given for determining pairs of anticommuting  $P$ -orthogonal,  $P$ -skew-symmetric matrices.

**Complete elliptic integrals resulting from infinite integrals of Bessel functions**, S. Okui, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 3, 113-135 (July-Sept. 1974).

Key words: applied mathematics; Bessel functions; complete elliptic integrals; engineering; infinite integrals; modified Bessel functions; physics; signal statistics.

Infinite integrals of Bessel and modified Bessel functions reducible to complete elliptic integrals are compiled. These formulas are of great use in solving problems of applied mathematics, physics and engineering.

**The convex hull of the transposition matrices**, L. S. Joel, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 3, 137-138 (July-Sept. 1974).

Key words: combinatorial analysis; convex set; linear inequalities; permutations.



The convex hull of the  $n$  by  $n$  transposition matrices is characterized as the set of symmetric doubly stochastic matrices with trace  $n - 2$ . A similar characterization (with trace  $\geq n - 2$ ) is given for the convex hull of the union of transposition matrices and the identity matrix.

**Computational experience with an algorithm for finding the  $k$  shortest paths in a network**, D. R. Shier, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 3, 139-165 (July-Sept. 1974).

Key words: double-sweep method; graph;  $k$  shortest paths; network; network algorithms; shortest path.

A particular computer implementation of the Double-Sweep method for calculating the  $k$  shortest paths in a network is described. Results are presented for a series of computational experiments performed on rectangular grid networks.

**How bad is the Hadamard determinantal bound?**, C. R. Johnson and M. Newman, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 3, 167-169 (July-Sept. 1974).

Key words: determinant; expected value; Hadamard determinantal bound; uniform distribution.

The Hadamard bound for the determinant of an  $n$  by  $n$  matrix is a good one in that equality may be attained in a rich class of cases. However, the bound generally gives up a good deal, and we answer the title question "on the average." Assuming the entries of  $A = (a_{ij})$  are uniformly distributed over some interval symmetric about the origin, the expected value of the ratio of  $(\det A)^2$  to the square of the Hadamard bound is found to be  $(n!)/(n^n)$ . The expectations of the square of the Hadamard bound and of  $(\det A)^2$  are also computed individually, and their ratio turns out also to be  $(n!)/(n^n)$ .

## October-December

**Saddlepoints in P-pivot classes of skew matrices**, M. L. Stein, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 4, 181-191 (Oct.-Dec. 1974).

Key words: combinatorial equivalence; linear inequalities; linear programs; pivot operations; skew-symmetry.

A finite class of skew matrices can be associated via "principal pivots" with a self-dual linear system. Given a row index  $h$ , it is known that there is a skew matrix in the class with nonnegative  $h$ th row. Using this "saddlepoint theorem," we prove a similar result for nonpositive rows. An open question is whether such a class of skew matrices contains one with both a nonnegative row and a nonpositive row. We show that this "double saddlepoint property" holds for arbitrarily large degenerate cases and for all skew matrices of small order.

**Maximizing the number of spanning trees in a graph with  $n$  nodes and  $m$  edges**, D. R. Shier, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 4, 193-196 (Oct.-Dec. 1974).

Key words: combinatorial analysis; enumeration; graphs; maximization; spanning trees; trees.

The problem considered is that of determining, among all graphs on  $n$  nodes and  $m$  edges, those having the maximum number of spanning trees. The possible candidate graphs can be obtained by deleting some number  $k$  of edges from a complete  $n$ -node graph. For  $k \leq n/2$ , it is shown that the maximum occurs when the  $k$  edges are mutually nonadjacent.

**The field of values and spectra of positive definite multiples**, C. R. Johnson, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 4, 197-198 (Oct.-Dec. 1974).

Key words: eigenvalues; field of values;  $H$ -stable; positive definite matrix; spectrum.

Suppose  $0 \neq \lambda \in C$  and  $A \in M_n(C)$ . We show constructively that  $\lambda$  is an eigenvalue of  $HA$  for some  $H^* = H > 0$  if and only if  $\lambda = x^*Ax$  for some  $x \in C^n$ . The characterization of  $H$ -stable matrices is then an easy corollary.

**Automatic computing methods for special functions. Part II. The exponential integral  $E_n(x)$** , I. A. Stegun and R. Zucker, *J. Res. Nat. Bur. Stand. (U.S.)*, **78B** (Math. Sci.), No. 4, 199-215 (Oct.-Dec. 1974).

Key words: computer programs; continued fraction; exponential integral; key values; recurrence relation.

Accurate, automatic, efficient methods for computing the exponential integral  $E_n(x)$  are detailed and implemented in an American National Standard FORTRAN program. The driver program and test results are also included.

### 3.3. DIMENSIONS/NBS (Formerly Technical News Bulletin), ARTICLE TITLES ONLY

This monthly magazine is published to inform scientists, engineers, businessmen, industry, teachers, students, and consumers of the latest advances in science and technology, with primary emphasis on the work at NBS.

DIMENSIONS/NBS highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, DIMENSIONS/NBS reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing. Issued monthly.

#### January 1974

**DIM/NBS 58, No. 1, 1-24 (1974).**

Key words: air conditioners; clean air; drunk drivers; energy labeling; fundamental constants; irradiated foods; metric computer program; migrant camps; thermestesiometer.

Specifications in the Physical World

Catalysis for Clean Air

Bureau Tackles Energy Problem

Air Conditioners Will be Energy Labeled First

Highlights

A Look at Sanitary Conditions in Migrant Camps

When is Hot Pot Hot?

Taking the Drunk Driver's Measure

Irradiated Foods—Safe at Home?

Computer Program for Metric Conversion

Publications

#### February 1974

**DIM/NBS 58, No. 2, 25-48 (1974).**

Key words: Alaskan baseline study; consumer goods; door security; ferrite measurement; health hazards; industry incentives; international program; law enforcement; measurement system; weights and measures.

How Safe Are Consumer Goods?

Industry Incentives Program Underway

Scientific Cross-Fertilization

Highlights

Scientists Fight Chilblains and the Clock in Alaskan Oil Baseline Study

Measuring the National Measurement System

That Equity May Prevail

NBS Contributes to Ferrite Measurement in Stainless Welds and Castings

Reducing the Health Hazards of Poor Radioactivity Measurement

Burglars Beware!

Publications

#### March 1974

**DIM/NBS 58, No. 3, 49-72 (1974).**

Key words: atomic timekeeping; building technology; disaster studies; energy-saving building construction; energy squeeze; insulation; measuring energy utilization; miners (communications).

Facing the Energy Squeeze

Without Insulation Your Dollars Slip Away

Office Building to Slash Fuel Use

Measurement of Energy Utilization—An Instrumentation Challenge

NBS Helps Design Energy-Saving School

Home Energy Saving Tips from NBS

Where From Here?

Architects of Survival

Highlights

New "Voice" for Trapped Miners

Atomic Timekeeping 25 Years Later

Publications

#### April 1974

**DIM/NBS 58, No. 4, 74-96 (1974).**

Key words: aircraft failure; Copernicus; corrosion; length standard; lens calibration; police helmets; satellite time; sprinkler systems.

Aircraft Failure: Reconstructing the Event

Man and Cosmos Lecture Series

Police Helmets: How Safe?

Highlights

Dark Corners of Corrosion

Nursing Homes ... and a Fire Connection

Toward a New Standard of Length

Through a Glass, Clearly

At the Signal ... Via Satellite Time

Publications

#### May 1974

**DIM/NBS 58, No. 5, 97-120 (1974).**



Key words: blood banking; bone cement; clinical lab; clinical SRM's; dental research; health research; implant materials; lead paint poisoning; MUMPS; protein adsorption; thermometry.

Accuracy of Clinical Lab Tests is Upgraded

SRM's Help Improve Health Measurements

They Don't Take Temperature Like They Used To

Solving the Lead Paint Problem

The NBS Reactor: Tool for Health Research

Getting It Together Polymerically

New Computer Language Standard Aids Medicine

Study on Blood Banking Bears Interest

NBS Marks 55 Years of Dental Research

Protein Adsorption Applied to Blood Compatibility

Highlights

Publications

### June 1974

**DIM/NBS 58, No. 6, 121-142 (1974).**

Key words: effects of metrication; environmental data; fire research (history of); fire retardants; flammability; frequency measurements; housing industry; Josephson junction; nitric oxide; synchrotron; ultraviolet machine.

New Fire Research Building

A Look at Fire Research

NBS Research Goes Back More Than 70 Years

Flammability: A New Look at an Age-Old Problem

From Thales to Josephson

Highlights

Effects of Metrication on the U.S. Economy

Metrication and the Housing Industry

NBS Develops Nitric Oxide Monitor

Latest Publications on Fire Research

New Ultraviolet Machine Will Outshine the Sun

Validation of Environmental Data

Publications

### July 1974

**DIM/NBS 58, No. 7, 145-168 (1974).**

Key words: bus experiment; charcoal grill safety; computer privacy and security; computer standards proposed; electroexplosive devices; energy monitored; jerry-can standard; materials conservation; noise pollution; voltage transfer.

Privacy and Security: Twin Challenges to Computer Technology

Edward Uhler Condon

Sounds That Hurt

Noise Pollution Grows

Waste Not, Want Not

NBS Programs Promote Materials Durability

Highlights

NBS Urges Charcoal Grill Safety

Bus Experiment Aids Commuter, Energy Conservation, Environment

New Voltage Transfer Technique

Stray Energy Monitored

New Computer Standards Proposed

JILA Fellows Named

Jerry-Can Standard Approved

Two Standards Under Review

Publications

### August 1974

**DIM/NBS 58, No. 8, 169-192 (1974).**

Key words: Big G; bolometer calibration; earthquake prediction; frequency standard systems; heat-pipe ovens; Hoover; liquefied natural gas; magnetometer; mechanical failure; microwaves; oscillator calibration.

Making the Most of a Limited Resource

Getting Through with Microwaves

How Big is G

Hoover at Commerce: "Satisfying Years"

Mechanical Failure—A Material Matter

Highlights

NBS Automates Bolometer Calibrations

Magnetic Eye Spots Weak Tanks

More Versatile Heat-Pipe Ovens Developed

Magnetometer May Help Predict Earthquakes

Guide to Courtroom Systems Prepared

Color TV Used to Calibrate Oscillators

Frequency Standard Systems Compare Atomic Time Scales

Publications

### September 1974

**DIM/NBS 58, No. 9, 193-215 (1974).**

Key words: auto paint; chlorine monitor; color measurements; color use; postdoctoral appointments; retroreflectors; semiconductor technology; thermocouple data; video tape; warning lights; weights and measures.

Standardization for Measuring Color

Greater Visibility Sought for Warning Lights

Collection of Auto Paint Colors Prepared for Forensic Use

NBS Publishes Book on Color Use

Program Provides Basis for Color and Appearance Measurements

Retroreflectors: Light in the Night

Highlights

New NBS Chlorine Monitor Aids Pollution Control

Video Tape Presentations on Semiconductor Technology Begun by NBS

Consumer Measures Adopted at Weights and Measures Conference

22 Named in NBS Postdoctoral Competition

NBS Test Method Adopted as Tentative Standard by NFPA

New Data for Thermocouple Users Issued

Getting from Square 1 to Square 2

Publications

### **October 1974**

**DIM/NBS 58**, No. 10, 217-239 (1974).

Key words: appliance labeling; Avogadro constant; biomolecules, computers; energy; EPIC; ground ladders; metrology guides; sales seminars; standardization and measurement; time and frequency.

Avogadro Constant Determination Sparks Advances in Measurement Science

NBS Assists Industry and Commerce with an EPIC

Conserving Energy Through Appliance Labeling

Technical Sales Seminars Open Doors Overseas

Biomolecules in the Sky

Highlights

New Standards for Ground Ladders Urged

Time and Frequency Texts Published

World War III Being Fought with Computers?

Workshop on Standardization and Measurement Services to be Held

First NBS-AIA Research Resident Named

New Metrology Guide Series Begun

Publications

### **November 1974**

**DIM/NBS 58**, No. 11, 241-263 (1974).

Key words: automation; computers innovation; energy conservation; fish story; lead paint; low-cost housing; privacy; R&D systems; robots.

Mankind and the Technological Imperative

Robots—Now and in the Future

A Modern Fish Story

Watch Your Step!

Highlights

Procurement, Regulatory and R&D Systems Used to Spur Technological Innovation

Office of Energy Conservation Established

4,000 Residences Surveyed for Lead Paint Problems

Low-Cost Housing Performance Examined

NBS Report Spells Out Privacy Proposals

Publications

### **December 1974**

**DIM/NBS 58**, No. 12, 265-288 (1974).

Key words: computer vote; cost-sharing; cryogenic data; earthquake; energy; grain alcohol; measurement science; pollution; screw threads; smoke and gas fatalities; waster; water.

Cost-Sharing to Help Clean Our Waterways

Energy from Waste

Grain Alcohol Detected in Space

Screw Thread Standards—Who Needs Them?

Measurement Science in Transition

Highlights

Reduction of Earthquake Losses Sought

Test Patterns for Integrated Circuits

NBS Developing Guidelines for Computer Vote Counting

Cryogenic Data Compiled by NBS

NBS Circulates Recommended Standards for School Paste

Three Studies of Smoke and Gas Fatalities Funded

Index

Publications



### 3.4. PAPERS FROM THE JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA, VOLUME 1, JANUARY-DECEMBER 1972

This journal is published quarterly by the American Chemical Society and the American Institute of Physics for the National Bureau of Standards. The objective of the Journal is to provide critically evaluated physical and chemical property data, fully documented as to the original sources and the criteria used for evaluation. Critical reviews of measurement techniques, whose aim is to assess the accuracy of available data in a given technical area, are also included. The principal source for the Journal is the National Standard Reference Data System (NSRDS). The Journal is not intended as a publication outlet for original experimental measurements such as are normally reported in the primary research literature, nor for review articles of a descriptive or primarily theoretical nature.

#### Volume 1, No. 1

**Gaseous diffusion coefficients**, T. R. Marrero and E. A. Mason, *J. Phys. Chem. Ref. Data* **1**, No. 1, 3-118 (1972).

Key words: binary gas mixtures; critically evaluated data; diffusion; diffusion coefficients; gases; transport properties.

Diffusion coefficients of binary mixtures of dilute gases are comprehensively compiled, critically evaluated, and correlated by new semi-empirical expressions. There are seventy-four systems for which the data are sufficiently extensive, consistent and accurate to allow diffusion coefficients to be recommended with confidence. Deviation plots are given for most of these systems. Almost every gaseous diffusion coefficient which was experimentally determined and reported prior to 1970 can be obtained from the annotated bibliography and table of gas pairs.

A detailed analysis of experimental methods is given, and intercomparison of their results helps establish reliability limits for the data, which depend strongly on temperature. Direct measurements are supplemented by calculations based on knowledge of intermolecular forces derived from independent sources—molecular beam scattering for high temperatures, and London dispersion constants for low temperatures. In addition, diffusion coefficients for several mixtures are obtained from experimental data on mixture viscosities and thermal diffusion factors. Combination of all these results gives diffusion coefficients over a very extensive temperature range, from very low temperatures to 10 000 K.

All data are corrected for composition dependence and for quantum effects. New semi-empirical equations are derived for making such corrections easily.

**Selected values of critical supersaturation for nucleation of liquids from the vapor**, G. M. Pound, *J. Phys. Chem. Ref. Data* **1**, No. 1, 119-133 (1972).

Key words: critical supersaturation; data evaluation; homogeneous nucleation; phase change.

Selected values of critical supersaturation for homogeneous nucleation of droplets from the vapor and for heterogeneous nucleation of droplets on the natural stationary concentration of gaseous ions are tabulated and plotted, and a rationale is given for selection of these data.

**Selected values of evaporation and condensation coefficients for**

**simple substances**, G. M. Pound, *J. Phys. Chem. Ref. Data* **1**, No. 1, 135-146 (1972).

Key words: condensation coefficients; data evaluation; evaporation coefficients; phase change.

Tables of selected data on the coefficients of evaporation and condensation far from equilibrium for simple substances are presented, together with a rationale for the exclusion or choice of data and an estimate of the precision measure.

**Atlas of the observed absorption spectrum of carbon monoxide between 1060 and 1900 Å**, S. G. Tilford and J. D. Simmons, *J. Phys. Chem. Ref. Data* **1**, No. 1, 147-188 (1972).

Key words: absorption spectra; carbon monoxide; electronic transitions; identification atlas; potential energy curves; rotational and vibrational constants.

This atlas summarizes the results of a recent investigation of the carbon monoxide absorption spectrum between 1060 and 1900 Å. Twelve electronic transitions are observed in this region; four electric dipole allowed electric transitions from the ground state  $X^1\Sigma^+$  to the  $A^1\Pi$ ,  $B^1\Sigma^+$ ,  $C^1\Sigma^+$ , and  $E^1\Pi$  states, and eight forbidden transitions to the  $a'^3\Sigma^+$ ,  $e^3\Sigma^-$ ,  $a^3\Pi$ ,  $D^1\Delta$ ,  $d^3\Delta_i$ ,  $I^1\Sigma^-$ ,  $j^3\Sigma^+$ , and  $c^3\Pi$  states. The following items are presented in the atlas: (1) A photograph of the spectrum with band assignments; (2) a table of band head measurements and assignments arranged by wavelength; (3) a summary of the spectroscopic constants and potential curve for each electronic state; (4) a line list, arranged by wavelength, of the observed rotational lines of the allowed transitions.

**Tables of molecular vibrational frequencies. Part 5**, T. Shimanouchi, *J. Phys. Chem. Ref. Data* **1**, No. 1, 189-216 (1972).

Key words: fundamental frequencies; infrared spectra; polyatomic molecules; Raman spectra; vibrational frequencies.

The compilations of fundamental vibrational frequencies of molecules previously published as NSRDS-NBS-6, NSRDS-NBS-11, NSRDS-NBS-17, and NSRDS-NBS-39, are extended to 58 additional molecules. Selected values of the fundamental vibrational frequencies are given for each molecule, together with observed infrared and Raman spectral data and citations to the original literature. The selection of vibrational fundamentals has been based on careful studies of the spectral data and comprehensive normal-coordinate analyses. An estimate of the accuracy of the selected values is included. The tables provide a convenient source of information for those who require vibrational energy levels and related properties in molecular spectroscopy, thermodynamics, analytical chemistry, and other fields of physics and chemistry.

#### Volume 1, No. 2

**Selected values of heats of combustion and heats of formation of organic compounds containing the elements C, H, N, O, P, and S**, E. S. Domalski, *J. Phys. Chem. Ref. Data* **1**, No. 2, 221-277 (1972).

Key words: CHNOPS compounds; heat of combustion; heat of formation; selected values.

Selected values of the heats of combustion and heats of forma-



tion of 719 organic compounds are reported here. The data tabulated pertain to compounds containing the elements carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur (CHNOPS). The information is arranged according to classes of compounds and within each class, compounds are arranged by empirical formula. The general classes covered are: hydrocarbons, alcohols, phenols, polyols, ethers, aldehydes, ketones, acids, acid anhydrides, esters, steroids, lactones, carbohydrates, heterocyclic oxygen compounds, amines, amides, urea derivatives, guanidine derivatives, amino acids, peptides, alkaloids, heterocyclic nitrogen compounds, porphyrins, organic sulfur compounds, and organic phosphorus compounds. When a selection was made from among several investigators, commentary is provided to indicate the choice, and usually some relevant data. The number of references cited is 596. An alphabetical compound index is provided which gives the name, page number, empirical formula, and the Wiswesser Line Notation (WLN), for each compound.

**Thermal conductivity of the elements**, C. Y. Ho, R. W. Powell, and P. E. Liley, *J. Phys. Chem. Ref. Data* **1**, No. 2, 279-421 (1972).

Key words: conductivity; critically evaluated data; data compilation; elements; reference data; thermal conductivity; transport properties.

This is the abridged version of a comprehensive volume on the thermal conductivity of the elements. It contains recommended reference values resulting from critical evaluation, analysis, and synthesis of all the available data. It also gives estimated values for those elements for which no thermal conductivity data are available. Thus, the work provides recommended or estimated thermal conductivity values for all the elements over the full temperature ranges where experimental data are available or reliable extrapolations or estimations can be made. The results on each element are presented in both graphical and tabular forms. Summary graphs arranged by group in the periodic table are also given.

**The spectrum of molecular oxygen**, P. H. Krupenie, *J. Phys. Chem. Ref. Data* **1**, No. 2, 423-534 (1972).

Key words: critical review; electronic spectrum; molecular oxygen; potential energy curves; rotational spectrum; spectroscopic constants.

This is a critical review and compilation of the observed and predicted spectroscopic data on  $O_2$  and its ions  $O_2^-$ ,  $O_2^+$ , and  $O_2^{2+}$ . The ultraviolet, visible, infrared, Raman, microwave, and electron paramagnetic resonance spectra are included. Each electronic band system is discussed in detail, and tables of band origins and heads are given. The microwave and EPR data are also tabulated. Special subjects such as the dissociation energy of  $O_2$ , perturbations, and predissociations are discussed. Potential energy curves are given, as well as  $f$ -values, Franck-Condon integrals, and other intensity factors. A summary table lists the molecular constants for all known electronic states of  $O_2$  and  $O_2^+$ . Electronic structure and theoretical calculations are also discussed.

**A critical review of the gas-phase reaction kinetics of the hydroxyl radical**, W. E. Wilson, Jr., *J. Phys. Chem. Ref. Data* **1**, No. 2, 535-573 (1972).

Key words: activation energy; chemical kinetics; combustion; rate constant; review.

The literature pertinent to reactions of the hydroxyl radical has been reviewed. An extensive discussion is given for reactions of the hydroxyl radical with itself and with  $CO$ ,  $H_2$ , and  $CH_4$ . These four reactions are: (1)  $OH + OH \rightarrow H_2O + O$ ; (2)  $CO + OH \rightarrow CO_2 + H$ ; (3)  $H_2 + OH \rightarrow H_2O + H$ ; (4)  $CH_4 + OH \rightarrow CH_3 + H_2O$ .

Values are recommended for  $k_1$  and  $k_2$  and for the ratio  $k_3/k_2$

and  $k_4/k_2$ . These rate ratios are used with the previously established value of  $k_2$  to obtain recommended values for  $k_3$  and  $k_4$ .

The recommended values in  $cm^3 \text{ mol}^{-1} \cdot s^{-1}$ , the temperature range, and the uncertainty are:

$$k_1 = 1.55 \times 10^{12}, 300 \text{ K}, \log k \pm .5^1$$

$$k_2 = 3.1 \times 10^{11} \exp(-300/T), 300\text{-}2000 \text{ K}, \log k \pm .3$$

$$k_3/k_2 = 73 \exp(2300/T), 300\text{-}2000 \text{ K}, \log k_3/k_2 \pm .3$$

$$k_3 = 3.8 \times 10^{13} \exp(-2600/T), 300\text{-}2000 \text{ K}, \log k \pm .3$$

$$k_4/k_2 = 92 \exp(2200/T), 300\text{-}2000 \text{ K}, \log k_4/k_2 \pm .3$$

$$k_4 = 2.85 \times 10^{13} \exp(-2500/T), 300\text{-}2000 \text{ K}, \log k \pm .7.$$

Rate expressions are also recommended for a number of other hydroxyl reactions whose rates are less well established.

## Volume 1, No. 3

**Molten salts: Volume 3, nitrates, nitrites, and mixtures. Electrical conductance, density, viscosity, and surface tension data**, G. J. Janz, U. Krebs, H. F. Siegenthaler, and R. P. T. Tomkins, *J. Phys. Chem. Ref. Data* **1**, No. 3, 581-746 (1972).

Key words: data compilation; density; electrical conductance; molten salt mixtures; nitrates; nitrites; standard reference data; surface tension; viscosity.

Data on the electrical conductance, density, viscosity, and surface tension of nitrate-nitrate, nitrite-nitrite, and nitrite-nitrate mixtures have been systematically collected and evaluated. Results are given for some 71 binary mixtures over a range of compositions and temperatures. Values of the above properties for the single salts have been updated in accord with previously advanced recommendations.

**High temperature properties and decomposition of inorganic salts. Part 3. Nitrates and nitrites**, K. H. Stern, *J. Phys. Chem. Ref. Data* **1**, No. 3, 747-772 (1972).

Key words: nitrates; nitrites; thermal decomposition; thermodynamic functions.

The literature dealing with the high-temperature behavior of inorganic nitrates and nitrites has been critically reviewed. Values of  $(G_T^\circ - H_{298}^\circ)/T$  of the reactants and products of the decomposition reactions were calculated and have been tabulated from 298 K up to as high a temperature as possible. Equilibrium constants and partial pressures were tabulated. Auxiliary data on phase transitions and densities have also been included. Qualitative information about the thermal decomposition of the salts is reviewed.

**High-pressure calibration. A critical review**, D. L. Decker, W. A. Bassett, L. Merrill, H. T. Hall, and J. D. Barnett, *J. Phys. Chem. Ref. Data* **1**, No. 3, 773-836 (1972).

Key words: calibration of pressure scales; critically evaluated data; high pressure; high pressure phase changes; pressure measurement.

A critical review of experimental technique for measuring high pressures has been made. The broad coverage includes discussions relating to (a) the establishment of a primary pressure scale using the free-piston gage, (b) the selection and precise measurement of identifiable phase changes as fixed pressure points, and (c) the use of interpolation and extrapolation techniques such as resistance gages, equations of state, and optical changes. The emphasis is on static pressure measurements above 10 kbar, but shock measurements are also considered for completeness. The pressure values to be associated with the fixed points have been analyzed in detail. Temperature measurement in the high pres-



sure environment is also reviewed. The accuracy with which pressures can be measured has been carefully considered; the maximum accuracies now obtainable are considered to be of the order of 0.02 percent at 8 kbar, 0.25 percent at 25 kbar, 2 percent at 50 kbar, and 4 percent at 100 kbar.

## Volume 1, No. 4

**The surface tension of pure liquid compounds**, J. J. Jasper, *J. Phys. Chem. Ref. Data* **1**, No. 4, 841-1010 (1972).

Key words: evaluated data; liquids; surface tension; thermodynamics of liquids.

The surface tension tables presented herein are the result of a literature survey, evaluation, and compilation of data of some 2200 pure liquid compounds, 226 of which were reported for a single temperature. These are arranged with related compounds in the increasing order of their molecular weights. As far as possible the method of measurement, nature of atmosphere to which the liquid was exposed during measurements, and the estimated accuracy are given for each liquid. The tabulated values were calculated from the derived results of directly measured quantities reported in the literature of many countries from about 1874 to 1969. Preliminary plots of the experimentally measured quantities indicated that the surface tensions of the liquid compounds are linear functions of the temperature over the reported operational range. The principle of least squares was applied to experimental surface tension values to establish the regression curves and their equations. The constants of the equations (slope and intercept), together with the standard deviations are given for each compound. The selection factors establishing criteria of quality of surface tension data are discussed. These include (a) method of measurement, (b) purity of compound, (c) quality of apparatus and assembly, (d) experimental procedure (experimentation), (e) reliability of measurements (most probable values), (f) experience of investigator, and (g) availability of data. There are 274 references listed alphabetically.

**Microwave spectra of molecules of astrophysical interest. I. Formaldehyde, formamide, and thioformaldehyde**, D. R. Johnson, F. J. Lovas, and W. H. Kirchhoff, *J. Phys. Chem. Ref. Data* **1**, No. 4, 1011-1046 (1972).

Key words: formaldehyde; formamide; interstellar molecules; microwave spectra; molecular parameters; radio astronomy; rotational transitions; thioformaldehyde.

The available data on the microwave spectra of formaldehyde, formamide, and thioformaldehyde are critically reviewed for information applicable to radio astronomy. Molecular data such as rotational constants, centrifugal distortion parameters, dipole moments, hyperfine coupling constants, and structural parameters are tabulated. Observed rotational transitions are presented for the astronomically interesting isotopic forms of these molecules when available. Detailed centrifugal distortion calculations have been carried out for the most abundant isotopic

forms of these molecules, namely,  $\text{H}_2^{12}\text{C}^{16}\text{O}$ ,  $\text{H}_2^{13}\text{C}^{16}\text{O}$ ,  $^{14}\text{NH}_2^{12}\text{CH}^{16}\text{O}$ , and  $\text{H}_2^{12}\text{C}^{32}\text{S}$ . Transitions have been predicted and tabulated for the frequency ranges

1 MHz to 300 GHz for  $\text{H}_2^{12}\text{C}^{16}\text{O}$ ,

100 MHz to 300 GHz for  $\text{H}_2^{13}\text{C}^{16}\text{O}$ ,

500 MHz to 180 GHz for  $^{14}\text{NH}_2^{12}\text{CH}^{16}\text{O}$ ,

and

100 MHz to 300 GHz for  $\text{H}_2^{12}\text{C}^{32}\text{S}$ .

All predicted transitions include 95 percent confidence limits; measured transition error limits have been reproduced from the original literature. References are given for all data included.

**Osmotic coefficients and mean activity coefficients of uni-univalent electrolytes in water at 25 °C**, W. J. Hamer and Y.-C. Wu, *J. Phys. Chem. Ref. Data* **1**, No. 4, 1047-1100 (1972).

Key words: activity coefficients; critically evaluated data; excess Gibbs energy for electrolytes; osmotic coefficients.

This paper gives values for the osmotic coefficients and mean activity coefficients of uni-univalent electrolytes in aqueous solutions at 25 °C. The values are expressed on the molality or weight basis. The data available in the literature have been corrected to the presently accepted scales of atomic weights (1969) and temperature (IPST 1968) and, where necessary, to the absolute electrical units of 1969 and the fundamental constants of 1963. The selected values of osmotic coefficients and mean activity coefficients for individual electrolytes have been made internally consistent thermodynamically. In some cases estimated values are given; in other cases, references only are given when the data are sparse or unsuited to critical evaluation. Values of the osmotic coefficients and mean activity coefficients of 79 compounds are given together with the standard deviation, variance, and normalized standard deviation of their fit to equations which express these quantities as functions of electrolyte concentration. Finally, literature references are given to data on 51 additional uni-univalent electrolytes.

**The viscosity and thermal conductivity coefficients of gaseous and liquid fluorine**, H. J. M. Hanley and R. Prydz, *J. Phys. Chem. Ref. Data* **1**, No. 4, 1101-1114 (1972).

Key words: critically evaluated data; fluorine; kinetic theory; modified Enskog theory; thermal conductivity; viscosity.

Tables of values for the viscosity and thermal conductivity of fluorine are presented in the range 70-300 K for pressures up to 200 atmospheres. Experimental results were reviewed but were judged to be unreliable. Accordingly, dilute gas values were determined from kinetic theory using the  $m$ -6-8 potential, and dense gas and liquid values were obtained from the modified Enskog theory. The critical point anomaly in the thermal conductivity coefficient is also discussed.

# PAPERS FROM THE JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA, VOLUME 2, JANUARY-DECEMBER 1973

## Volume 2, No. 1

**Microwave spectra of molecules of astrophysical interest. II. Methylenimine.** W. H. Kirchhoff, D. R. Johnson, and F. J. Lovas, *J. Phys. Chem. Ref. Data* **2**, No. 1, 1-10 (1973).

Key words: hyperfine structure; interstellar molecules; methylenimine; microwave spectra; molecular parameters; radio astronomy; rotational transitions.

The available data on the microwave spectrum of methylenimine are critically reviewed for information applicable to radio astronomy. Molecular data such as rotational constants, centrifugal distortion parameters, hyperfine coupling constants, and dipole moments are tabulated. A detailed centrifugal distortion calculation has been carried out for the most abundant isotopic form of this molecule,  $H_2\ ^{12}C\ ^{14}NH$ . Transitions have been predicted and tabulated for the frequency range 100 MHz to 300 GHz. All predicted transitions include 95 percent confidence limits; error limits have been reported for all measured transitions.

**Analysis of specific heat data in the critical region of magnetic solids.** F. J. Cook, *J. Phys. Chem. Ref. Data* **2**, No. 1, 11-24 (1973).

Key words: critical exponents; critical phenomena; data analysis; magnetic solids; nonlinear least-squares; phase transitions; specific heat; static scaling.

A detailed analysis of specific heat data in the critical region of magnetic solids is presented. An inverse power law, whose strength is measured by the exponent  $\alpha$ , is used to describe the temperature dependence of the magnetic specific heat. Other parameters used include the power law coefficient  $A$ , the critical temperature  $T_c$ , and a constant background term  $B$ . Advanced techniques of data analysis suitable for estimation of nonlinear parameters and their errors under conditions of realistically weighted experimental data were used to obtain the dependence of  $\alpha$ ,  $T_c$ ,  $A$ , and  $B$  on the range of data points included in the fit. Those exponents and parameters that provide the best overall fit to the data have been found. Literature references to 49 experiments from 1935 to 1971 are given. We present in tabular form the values of  $\alpha$ ,  $A$ , and  $B$  for 24 different magnetic crystals. With some exceptions, the best fits to the data suggest that in the temperature range studied the magnetic specific heat is not symmetric; the exponent  $\alpha$  depends on the range of data included in the fit, varies widely from material to material, and in many cases is definitely negative below the critical temperature; and that there is little evidence that the asymptotic region is being adequately sampled by experiment. These results have the implication that until such time as we can adequately account for departures from the expected sharp peak in the data at  $T_c$  (data rounding) and corrections to asymptotic scaling, then comparisons between magnetic specific heat experiments and lowest order scaling predictions are to this date still tenuous.

**Evaluated chemical kinetic rate constants for various gas phase reactions.** K. Schofield, *J. Phys. Chem. Ref. Data* **2**, No. 1, 25-84 (1973).

Key words: activation energies; evaluation; gaseous reactions; radical reactions; rate constants; review; sulfur chemistry; tables.

The available information, up to mid-1972, for the rate constants of a series of gas phase chemical reactions has been evalu-

ated critically. For each reaction, relevant thermodynamic data are presented and values for the equilibrium constant expressed in mathematical form. Kinetic data are presented in tabular and graphical form together with a discussion of the pertinent details. Recommended rate constant values are presented wherever possible with suggested error limits. The reactions considered involve the species  $H$ ,  $O$ ,  $C$ ,  $N$ ,  $S$ ,  $OH$ ,  $HS$ ,  $S_2$ ,  $CS$ ,  $SO$ ,  $HSO_2$ ,  $NH_2$ ,  $NH_3$ ,  $NO$ ,  $N_2O$ ,  $NO_2$ ,  $N_2O_4$ ,  $N_2$ ,  $O_2$ ,  $O_3$ ,  $H_2$ ,  $H_2O$ ,  $SO_2$ ,  $SO_3$ ,  $CS_2$ ,  $OCS$ ,  $H_2S$ , and  $CO$ . Particular emphasis is given to reactions involving sulfur chemistry. The best available data for these reactions have been summarized in a table at the end of the paper. An appendix discussing the available evaluations and review articles published since 1960 also has been included to publicize these sources of either evaluated data or of extensive reference bibliographies.

**Atomic transition probabilities for forbidden lines of the iron group elements. (A critical data compilation for selected lines).** M. W. Smith and W. L. Wiese, *J. Phys. Chem. Ref. Data* **2**, No. 1, 85-120 (1973).

Key words: chromium; cobalt; forbidden transitions; iron; manganese; nickel; transition probabilities; vanadium.

Atomic transition probabilities for about 750 forbidden spectral lines for elements of the iron group, specifically V, Cr, Mn, Fe, Co, and Ni, have been critically evaluated and compiled using all available literature sources. The selection of the spectra and elements has been made primarily according to their astrophysical importance. The data are presented in separate tables for each element and stage of ionization, and for each ion the data are arranged according to multiplets. For each line within a multiplet the transition probability for spontaneous emission is listed along with the standard spectroscopic designation, the wavelength, the statistical weights, and the energy levels of the upper and lower states. In addition, the estimated accuracy and the source are indicated. In short introductions which precede the individual tables for the ions the main justifications for the choice of the adopted data and for the accuracy rating are discussed. A general introduction contains a detailed discussion of the critical factors entering into the calculations. It also includes detailed comparisons of calculated data with astrophysical observations and a few laboratory results, which serve as a valuable indication for the validity of the estimated accuracies.

**Tables of molecular vibrational frequencies. Part 6.** T. Shimanouchi, *J. Phys. Chem. Ref. Data* **2**, No. 1, 121-161 (1973).

Key words: fundamental frequencies; infrared spectra; polyatomic molecules; Raman spectra; vibrational frequencies.

The compilations of fundamental vibrational frequencies of molecules previously published in the NSRDS-NBS publication series and in this journal are here extended to 55 additional molecules. Selected values of the fundamental vibrational frequencies are given for each molecule, together with observed infrared and Raman spectral data and citations to the original literature. The selection of vibrational fundamentals has been based on careful studies of the spectral data and comprehensive normal-coordinate analyses. An estimate of the accuracy of the selected values is included. The tables provide a convenient source of information for those who require vibrational energy levels and related properties in molecular spectroscopy, ther-



modynamics, analytical chemistry, and other fields of physics and chemistry.

**Compilation of energy band gaps in elemental and binary compound semiconductors and insulators**, W. H. Strehlow and E. L. Cook, *J. Phys. Chem. Ref. Data* 2, No. 1, 163-199 (1973).

Key words: band gaps; binary compounds; electronic properties; insulators; semiconductors.

Energy band gaps are tabulated for elemental and binary compound semiconductors and insulators reported in 723 references. The method of measurement, transition, type of sample, and other pertinent information are included for each entry. The determinations believed to be the most reliable are indicated.

## Volume 2, No. 2

**Microwave spectra of molecules of astrophysical interest. III. Methanol**, R. M. Lees, F. J. Lovas, W. H. Kirchhoff, and D. R. Johnson, *J. Phys. Chem. Ref. Data* 2, No. 2, 205-214 (1973).

Key words: internal rotation; interstellar molecules; methanol; microwave spectra; molecular parameters; radio astronomy; rotational transitions; torsion.

The available data on the microwave spectrum of methanol are critically reviewed for information applicable to radio astronomy. Molecular data such as moments and product of inertia, torsional potential constants, centrifugal distortion and torsion-rotation interaction constants, dipole moment, and structural parameters are tabulated. Observed rotational transitions are presented for the astronomically interesting isotopic forms of methanol when available. Detailed centrifugal distortion and torsion-rotation interaction calculations have been carried out for the most abundant isotopic form of methanol. Transitions are tabulated for the frequency range from 500 MHz to 200 GHz. Measured transition error limits have been reproduced from the original literature. References are given for all data included.

**Microwave spectra of molecules of astrophysical interest. IV. Hydrogen sulfide**, P. Helminger, F. C. De Lucia, and W. H. Kirchhoff, *J. Phys. Chem. Ref. Data* 2, No. 2, 215-223 (1973).

Key words: hydrogen sulfide; hyperfine structure; interstellar molecules; microwave spectra; molecular parameters; radio astronomy; rotational transitions.

The available data on the microwave spectrum of hydrogen sulfide are critically reviewed for information applicable to radio astronomy. Molecular data such as rotational constants, centrifugal distortion constants, hyperfine coupling parameters, and dipole moments are tabulated. A detailed centrifugal distortion calculation has been carried out for the most abundant isotopic form of this molecule,  $\text{H}_2^{32}\text{S}$ , as well as for  $\text{HD}^{32}\text{S}$ . Transitions have been predicted and tabulated for the frequency range 1 MHz to 1000 GHz for  $\text{H}_2^{32}\text{S}$  and 1 MHz to 700 GHz for  $\text{HD}^{32}\text{S}$ . All predicted transitions include 95 percent confidence limits; estimated error limits have been reported for all measured transitions. Observed transitions of  $\text{H}_2^{32}\text{S}$  and  $\text{H}_2^{34}\text{S}$  are also listed.

**Tables of molecular vibrational frequencies. Part 7**, T. Shimanouchi, *J. Phys. Chem. Ref. Data* 2, No. 2, 225-256 (1973).

Key words: fundamental frequencies; infrared spectra; polyatomic molecules; Raman spectra; vibrational frequencies.

The compilations of fundamental vibrational frequencies of molecules previously published in the NSRDS-NBS publication series and in this journal are here extended to 50 additional molecules. Selected values of the fundamental vibrational frequencies are given for each molecule, together with observed infrared and Raman spectral data and citations to the original

literature. The selection of vibrational fundamentals has been based on careful studies of the spectral data and comprehensive normal-coordinate analyses. An estimate of the accuracy of the selected values is included. The tables provide a convenient source of information for those who require vibrational energy levels and related properties in molecular spectroscopy, thermodynamics, analytical chemistry, and other fields of physics and chemistry.

**Energy levels of neutral helium ( $^4\text{He}$  I)**, W. C. Martin, *J. Phys. Chem. Ref. Data* 2, No. 2, 257-265 (1973).

Key words: atomic energy levels; atomic spectra; autoionization; electron scattering; fine structure; helium; photoionization resonances; photon absorption.

This compilation of all identified levels is based on the most accurate available observations. It includes 48 levels above the  $\text{He II } 1^2\text{S}$  limit (two-electron excitation).

**Survey of photochemical and rate data for twenty-eight reactions of interest in atmospheric chemistry**, R. F. Hampson, Ed., W. Braun, R. L. Brown, D. Garvin, J. T. Herron, R. E. Huie, M. J. Kurylo, A. H. Laufer, J. D. McKinley, H. Okabe, M. D. Scheer, W. Tsang, and D. H. Stedman, *J. Phys. Chem. Ref. Data* 2, No. 2, 267-311 (1973).

Key words: atmospheric chemistry; chemical kinetics; data evaluation; gas phase reactions; optical absorption coefficients; photochemistry; quantum yields; rate constants.

Photochemical and rate data have been evaluated for 28 gas phase reactions of interest for the chemistry of the stratosphere. The results are presented on data sheets, one per reaction. For each reaction, the available data are summarized. Where possible there is given a preferred value for the rate constant or, for the photochemical reactions, preferred values for primary quantum yields and optical absorption coefficients.

**Compilation of the static dielectric constant of inorganic solids**, K. F. Young and H. P. R. Frederikse, *J. Phys. Chem. Ref. Data* 2, No. 2, 313-409 (1973).

Key words: dielectric constant; dielectric loss; permittivity; static dielectric constant.

This compilation contains values of the static dielectric constant of more than 300 inorganic solids. The temperature and frequency of the measurements are listed and the magnitude of the loss tangent is indicated if known. For ninety materials—including most ferroelectrics and antiferroelectrics and several oxides and halides—additional information is presented in the form of graphs depicting the temperature dependence of the dielectric constant. In a few cases the frequency and pressure dependences are also shown. The basic principles and formulas pertinent to the field of dielectrics are reviewed in a short introduction. This part also mentions several measuring techniques and indicates the criteria used for data selection.

**Soft x-ray emission spectra of metallic solids: Critical review of selected systems**, A. J. McAlister, R. C. Dobbyn, J. R. Cuthill, and M. L. Williams, *J. Phys. Chem. Ref. Data* 2, No. 2, 411-426 (1973).

Key words: alloys; critical review; emission spectra; intermetallic compounds; metals; soft x-ray; spectra.

Theory and experimental practice in the field of soft x-ray emission from metallic solids are briefly reviewed, and measurements on a number of systems ( $\text{Al}$ ,  $\text{Al}$  in  $\text{AuAl}_2$ ,  $\text{Al}$  and  $\text{Mg}$  in  $\text{Al-Mg}$ ,  $\text{Cu}$ ,  $\text{Cu}$  and  $\text{Ni}$  in  $\text{Cu-Ni}$ ,  $\text{Li}$ ,  $\text{Mg}$ ,  $\text{Na}$ , and  $\text{Ni}$ ) are critically evaluated and compared with the results of other techniques and theory, with a view to establishing the pertinence of the soft x-ray measurements and indicating specific guidelines for enhancing their value.



**Ideal gas thermodynamic properties of ethane and propane, J. Chao, R. C. Wilhoit, and B. J. Zwolinski, *J. Phys. Chem. Ref. Data* 2, No. 2, 427-437 (1973).**

Key words: critically evaluated data; enthalpy; enthalpy function; enthalpy of formation; entropy; equilibrium constant of formation; ethane; Gibbs energy function; Gibbs energy of formation; heat capacity; ideal gas thermodynamic properties; internal rotation barrier height; internal rotation energy levels; propane; torsional frequencies.

The thermodynamic properties ( $C_p^\circ$ ,  $S^\circ$ ,  $H^\circ - H_0^\circ$ ,  $(H^\circ - H_0^\circ)/T$ ,  $-(G^\circ - H_0^\circ)/T$ ,  $\Delta H_f^\circ$ ,  $\Delta G_f^\circ$  and  $\log K_f$ ) for ethane and propane in the ideal gaseous state in the temperature range from 0 to 1500 K and at 1 atm were calculated by statistical thermodynamic methods based on a rigid-rotor harmonic-oscillator model. The internal rotation contributions to thermodynamic functions were evaluated by using a partition function formed by summation of internal rotation energy levels. The calculated heat capacities and entropies compare favorably with available experimental data.

## Volume 2, No. 3

**An analysis of coexistence curve data for several binary liquid mixtures near their critical points, A. Stein and G. F. Allen, *J. Phys. Chem. Ref. Data* 2, No. 3, 443-466 (1973).**

Key words: binary liquid mixtures; coexistence curve; consolute point; critically evaluated data; critical point; critical point exponent; diameter; power law; statistical analysis.

Experimental data on the coexistence curves for nine binary liquid systems, which meet strict criteria of precision, purity of components, and experimental method, are analyzed in the neighborhood of the critical point. The data are examined in terms of a general equation of state which is nonanalytic at the critical point. The results of the computer analysis using weighted non-linear least squares procedures present evidence that some symmetry features of classical equations of state remain; and within the experimental errors in the data all systems are consistent with the critical exponent  $\beta = 0.34$ . The asymptotic behavior of the diameter is examined and evidence is provided for a curved diameter in some cases; however, it is concluded that the available data are not extensive enough to make a firm conclusion concerning the shape of the diameter. Experimental methods are briefly criticized and mention is made of the experimental direction that future work should take. Special attention is given to estimating the reliability of the conclusions that may be drawn from a given set of data.

**Rate constants for the reactions of atomic oxygen ( $O(^3P)$ ) with organic compounds in the gas phase, J. T. Herrón and R. E. Huie, *J. Phys. Chem. Ref. Data* 2, No. 3, 467-518 (1973).**

Key words: atomic oxygen; chemical kinetics; compilation; critical evaluation; gases; organic compounds; rate constants.

Rate constants for the reactions of atomic oxygen ( $O(^3P)$ ) with organic compounds in the gas phase are compiled and critically evaluated. Data are given here as originally reported in the literature for a total of 107 organic reactants. From a critical evaluation of the data, recommended values for rate constants are given over specified temperature intervals, and where possible at 298 K and 1000 K. Estimated error limits are assigned to all recommended values.

**First spectra of neon, argon, and xenon 136 in the 1.2-4.0  $\mu\text{m}$  region, C. J. Humphreys, *J. Phys. Chem. Ref. Data* 2, No. 3, 519-530 (1973).**

Key words: argon; extraphotographic region; infrared emission spectra; intensities; neon; wavelengths; wavelength standards; wave numbers; xenon.

Descriptions of the first spectra of neon, argon, and xenon 136, comprising calculated wavelengths, calculated wave numbers, relative intensities, and classifications, are presented. The calculated values are derived from currently best established energy levels, obtained mostly from interferometric observations and adopted as standards by the International Astronomical Union. All listed lines have actually been observed. This paper makes available a compilation of all results previously presented in fragmentary or relatively inaccessible reports with intensities normalized to as nearly a uniform scale as the various observations permit.

**Elastic properties of metals and alloys. I. Iron, nickel, and iron-nickel alloys, H. M. Ledbetter and R. P. Reed, *J. Phys. Chem. Ref. Data* 2, No. 3, 531-618 (1973).**

Key words: bulk modulus; compressibility; elastic constant; Debye temperatures; iron; iron alloys; Lamé constants; nickel; nickel alloys; Poisson's ratio; shear modulus; single-crystal elastic coefficients; Young's modulus.

A comprehensive compilation is given of elastic properties of iron-nickel alloys. When sufficient data exist, preferred values are recommended. This compilation covers, besides pure iron and pure nickel, the entire binary composition range, both b.c.c. and f.c.c. phases. Elastic constants included are: Young's modulus, shear modulus, bulk modulus (reciprocal compressibility), Poisson's ratio, and single-crystal elastic stiffnesses, both second-order and higher-order. Data are compiled for variation of elastic constants with composition, temperature, pressure, magnetic field, mechanical deformation, annealing, and crystallographic transitions. An overview is given from the vantage points of the electron theory of metals, elasticity theory, and crystallographic theory. Also included are discussions of isothermal and adiabatic elastic constants, interrelationships among engineering elastic constants, computation of the latter from single-crystal elastic stiffnesses, and similar topics. Where key data have not been measured, they were generated if possible from existing data using standard formulae. Other gaps, both theoretical and experimental, in the elastic properties of iron-nickel alloys are indicated. A few theoretical results are included where experimental data are nonexistent or scarce. A semantic scheme is proposed for distinguishing elastic constants of solids.

**The viscosity and thermal conductivity coefficients of dilute argon, krypton, and xenon, H. J. M. Hanley, *J. Phys. Chem. Ref. Data* 2, No. 3, 619-642 (1973).**

Key words: dilute gas; kinetic theory;  $m$ -6-8 potential function; rare gases; thermal conductivity coefficient; viscosity coefficient.

The viscosity and thermal conductivity coefficients of dilute argon, krypton, and xenon are reviewed and tables of recommended values presented. The tables were generated using the appropriate kinetic theory expressions with the  $m$ -6-8 potential. The temperature range covers from about one-half critical temperature to 2000 K for each gas. A general estimate of the accuracy is one percent increasing to one and three-quarters percent for temperatures above 1000 K.

**Diffusion in copper and copper alloys. Part I. Volume and surface self-diffusion in copper, D. B. Butrymowicz, J. R. Manning, and M. E. Read, *J. Phys. Chem. Ref. Data* 2, No. 3, 643-656 (1973).**

Key words: copper; diffusion; electromigration; liquid copper diffusion; nuclear magnetic resonance and diffusion; pressure effects on diffusion; self-diffusion; sintering; surface diffusion; thermo-migration.

A survey, comparison, and critical analysis is presented of data compiled from the scientific literature concerning copper self-diffusion. Topics include volume diffusion, dislocation pipe diffusion, surface diffusion, sintering, electromigration, ther-



momigration, pressure effect on diffusion, strain-enhanced diffusion, nuclear magnetic resonance measurements of solid state diffusion and diffusion in molten copper. An extensive bibliography is presented along with figures, tabular presentation of data, and discussion of results.

## Volume 2, No. 4

**The 1973 least-squares adjustment of the fundamental constants,** E. R. Cohen and B. N. Taylor, *J. Phys. Chem. Ref. Data* **2**, No. 4, 663-734 (1973).

Key words: data analysis; fundamental constants; least-squares adjustments; quantum electrodynamics.

This paper is a summary of the 1973 least-squares adjustment of the fundamental physical constants carried out by the authors under the auspices of the CODATA Task Group on Fundamental Constants. The salient features of both the input data used and its detailed analysis by least-squares are given. Also included is the resulting set of best values of the constants which is to be recommended for international adoption by CODATA, a comparison of several of these values with those resulting from recent past adjustments, and a discussion of current problem areas in the fundamental constants field requiring additional research.

**The viscosity and thermal conductivity coefficients of dilute nitrogen and oxygen,** H. J. M. Hanley and J. F. Ely, *J. Phys. Chem. Ref. Data* **2**, No. 4, 735-756 (1973).

Key words: critically evaluated data; dilute polyatomic gas; kinetic theory of polyatomic molecules;  $m$ -6-8 potential; nitrogen; nonspherical interactions; oxygen; second virial coefficient; thermal conductivity coefficient; thermal diffusion factor; viscosity coefficient.

The viscosity and thermal conductivity coefficients of dilute oxygen and nitrogen are discussed and tables of values are presented for temperatures between 80 and 2000 K. The oxygen viscosity tables are estimated to be accurate to two percent for temperatures up to 400 K and four percent above that temperature; the nitrogen viscosity tables are estimated to be reliable to one percent in the range 100-1000 K, increasing to two percent above 1000 K and below 100 K. The error assigned to the thermal conductivity is three percent below 400 K and five percent above 400 K for both gases. The tables were calculated from the appropriate kinetic theory equations using the  $m$ -6-8 model potential with nonspherical contributions. The approximations to the equations are discussed. It is emphasized that the available data for oxygen viscosity are generally poor and that the thermal conductivity data for both oxygen and nitrogen cannot be considered reliable at high temperatures. No oxygen data exist for temperatures above 1500 K.

**Thermodynamic properties of nitrogen including liquid and vapor phases from 63 K to 2000 K with pressures to 10,000 bar,** R. T. Jacobsen and R. B. Stewart, *J. Phys. Chem. Ref. Data* **2**, No. 4, 757-922 (1973).

Key words: critically evaluated data; critical point; density;

enthalpy; entropy; equation of state; heat capacity; ideal gas properties; latent heat; nitrogen; second virial coefficient; vapor pressure; velocity of sound.

Tables of thermodynamic properties of nitrogen are presented for the liquid and vapor phases for temperatures from the freezing line to 2000 K and pressures to 10,000 bar. The tables include values of density, internal energy, enthalpy, entropy, isochoric heat capacity ( $C_v$ ), isobaric heat capacity ( $C_p$ ), velocity of sound, the isotherm derivative  $(\partial P/\partial \rho)_T$ , and the isochor derivative  $(\partial P/\partial T)_\rho$ . The thermodynamic property tables are based on an equation of state,  $P = P(\rho, T)$ , which accurately represents liquid and gaseous nitrogen for the range of pressures and temperatures covered by the tables. Comparisons of property values calculated from the equation of state with measured values for  $P$ - $\rho$ - $T$ , heat capacity, enthalpy, latent heat, and velocity of sound are included to illustrate the agreement between the experimental data and the tables of properties presented here. The coefficients of the equation of state were determined by a weighted least squares fit to selected  $P$ - $\rho$ - $T$  data and, simultaneously, to  $C_v$  data determined by corresponding states analysis from oxygen data, and to data which define the phase equilibrium criteria for the saturated liquid and the saturated vapor. The vapor pressure equation, melting curve equation, and an equation to represent the ideal gas heat capacity are also presented. Estimates of the accuracy of the equation of state, the vapor pressure equation, and the ideal gas heat capacity equation are given. The equation of state, derivatives of the equation, and the integral functions for calculating derived thermodynamic properties are included.

**Thermodynamic properties of helium 4 from 2 to 1500 K at pressures to  $10^8$  Pa,** R. D. McCarty, *J. Phys. Chem. Ref. Data* **2**, No. 4, 923-1042 (1973).

Key words: critically evaluated data; critical point; enthalpy; entropy; equation of state; helium; internal energy; Joule-Thomson coefficient; lambda line; melting line;  $P$ - $V$ - $T$ ; specific heat; speed of sound; vapor pressure; virial coefficient.

Tabular values of density, internal energy, enthalpy, entropy, heat capacity, and speed of sound for liquid and gaseous helium are presented for temperatures from 2 to 1500 kelvin at pressures from  $1.0 \times 10^4$  to  $1.0 \times 10^8$  pascals. Diagrams of temperature vs. entropy are also given. The properties presented are calculated from an equation of state which was fitted to experimental  $P$ - $V$ - $T$  and other thermodynamic data from the world's literature. The equation of state was fitted to these data in three separate regions of pressure and temperature. The regional equations are forced to join smoothly at the preconceived boundaries. Extensive comparisons between the equation of state and experimental data have been made, and deviation plots are presented. A particularly careful determination of the second virial coefficient over the full temperature range 2-1500 kelvin is presented. The Joule-Thomson inversion curve has been calculated and comparisons made with other sources. Equations for the density of the saturated liquid and vapor are included as well as an equation which represents the 1958 helium vapor pressure temperature scale.



# PAPERS FROM THE JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA, VOLUME 3, JANUARY-DECEMBER 1974

## Volume 3, No. 1

**Molten salts: Volume 4. Part I. Fluorides and mixtures. Electrical conductance, density, viscosity, and surface tension data,** G. J. Janz, G. L. Gardner, U. Krebs, and R. P. T. Tomkins, *J. Phys. Chem. Ref. Data* 3, No. 1, 1-115 (1974).

Key words: data compilation; density; electrical conductance; fluorides; molten salt mixtures; standard reference data; surface tension; viscosity.

Data on the electrical conductance, density, viscosity, and surface tension of fluoride mixtures have been systematically collected and evaluated. Results are given for 44 binary mixtures over a range of compositions and temperatures. Values of the above properties for the single salts have been updated in accord with previously advanced recommendations.

**Ideal gas thermodynamic properties of eight chloro- and fluoromethanes,** A. S. Rodgers, J. Chao, R. C. Wilhoit, and B. J. Zwolinski, *J. Phys. Chem. Ref. Data* 3, No. 1, 117-140 (1973).

Key words: chloromethane; critical evaluation of thermodynamic properties; fluoromethane; ideal gas thermodynamic properties.

The structural data, vibrational assignments, enthalpies of vaporization and formation for chloromethane, dichloromethane, trichloromethane, tetrachloromethane, fluoromethane, difluoromethane, trifluoromethane, and tetrafluoromethane were critically reviewed. Based on the selected best values, the thermodynamic properties for each of these eight chloro- and fluoromethanes were calculated by statistical thermodynamic methods using the rigid-rotor harmonic-oscillator approximations. The derived entropies and heat capacities are compared with the available third law entropies and vapor heat capacities. The calculated values of  $C_p^\circ$ ,  $S^\circ$ , and  $\Delta H_f^\circ$  at 298.15 and 700 K are compared with those reported in the other major compilations.

**Ideal gas thermodynamic properties of six chloroethanes,** J. Chao, A. S. Rodgers, R. C. Wilhoit, and B. J. Zwolinski, *J. Phys. Chem. Ref. Data* 3, No. 1, 141-162 (1973).

Key words: chloroethane with a symmetry top; ideal gas thermodynamic properties; internal rotation; internal rotation barrier heights; torsional fundamental.

The thermodynamic properties:  $C_p^\circ$ ,  $S^\circ$ ,  $H^\circ - H_0^\circ$ ,  $-(G^\circ - H_0^\circ)/T$ ,  $\Delta H_f^\circ$ ,  $\Delta G_f^\circ$ , and  $\log K_f$  for chloroethane, 1,1-dichloroethane, 1,1,1-trichloroethane, 1,1,1,2-tetrachloroethane, pentachloroethane, and hexachloroethane in the ideal gaseous state in the temperature range from 0 to 1500 K and at 1 atm were evaluated by statistical thermodynamic methods based on a rigid-rotor harmonic-oscillator model. The internal rotation contributions to thermodynamic functions were calculated by using a partition function formed by summation of internal rotation energy levels. The internal rotation barrier heights (in kcal mol<sup>-1</sup>) employed for generation of the energy levels for each of the above six chloroethanes are: 3.69, 3.54, 5.08, 10.38, 14.43, and 14.7, respectively. The calculated heat capacities and entropies are compared with available experimental data. The derived values of  $C_p^\circ$ ,  $S^\circ$ , and  $\Delta H_f^\circ$  at 298.15 and 700 K are compared with those reported in the other major compilations.

**Critical analysis of heat-capacity data and evaluation of thermodynamic properties of ruthenium, rhodium, palladium, iridium, and platinum from 0 to 300 K. A survey of the literature data on osmium,** G. T. Furukawa, M. L. Reilly, and J. S. Gallagher, *J. Phys. Chem. Ref. Data* 3, No. 1, 163-209 (1974).

Key words: calorimetry; critically evaluated data; Debye temperature ( $\theta$ ); electronic coefficient of heat capacity ( $\gamma$ ); enthalpy; entropy; Gibbs energy; heat capacity; iridium; osmium, palladium; platinum; rhodium; ruthenium; thermodynamic properties.

The literature sources of heat-capacity data on ruthenium, rhodium, palladium, osmium, iridium, and platinum have been compiled and the data critically analyzed. Except for osmium where data are lacking, best values of thermodynamic properties have been evaluated between 0 and 300 K from the analyses. The literature values of heat capacity, the electronic coefficient of heat capacity ( $\gamma$ ), and the zero K limiting Debye characteristic temperature ( $\theta_D(0)$ ) are compared. The sources of data are tabulated chronologically along with the temperature range of measurements, purity of sample, and the pertinent experimental procedures used. A bibliography of the references is listed.

**Microwave spectra of molecules of astrophysical interest. V. Water vapor,** F. C. De Lucia, P. Helminger, and W. H. Kirchhoff, *J. Phys. Chem. Ref. Data* 3, No. 1, 211-219 (1974).

Key words: hyperfine structure; interstellar molecules; microwave spectra; molecular parameters; radio astronomy; rotational transitions; water.

The available data on the microwave spectrum of water vapor are critically reviewed for information applicable to radio astronomy. Molecular data such as rotational constants, centrifugal distortion constants, hyperfine coupling parameters, and dipole moments are tabulated. A detailed centrifugal distortion calculation has been carried out for the most abundant isotopic form of this molecule  $H_2^{16}O$ , as well as for  $H_2^{18}O$  and  $HD^{16}O$ . Transitions have been predicted and tabulated for the frequency range 1 MHz to 800 GHz. All predicted transitions include 95 percent confidence limits; estimated error limits have been reported for all measured transitions. Observed transitions of  $H_2^{17}O$  are also listed.

**Microwave spectra of molecules of astrophysical interest. VI. Carbonyl sulfide and hydrogen cyanide,** A. G. Maki, *J. Phys. Chem. Ref. Data* 3, No. 1, 221-244 (1974).

Key words: carbonyl sulfide; hydrogen cyanide; interstellar molecules; microwave spectra; molecular parameters; radio astronomy; rotational transitions; spectra.

All available data on the microwave spectra of carbonyl sulfide and hydrogen cyanide are critically reviewed and tabulated. Molecular data such as rotational constants, centrifugal distortion constants, dipole moments, hyperfine coupling constants, and structural parameters are also tabulated. All rotational transitions from 100 MHz to 300 GHz that are deemed likely to be of interest to radio astronomers are calculated and tabulated along with their estimated 95 percent confidence limits. Microwave measurements are tabulated for most isotopic species and for many of the lower vibrational states. For both carbonyl sulfide and hydrogen cyanide a bibliography is given which includes nearly all the spectroscopic work reported in the literature. For each molecule a bibliography of related astrophysical papers is also given.



**Microwave spectra of molecules of astrophysical interest. VII. Carbon monoxide, carbon monosulfide, and silicon monoxide,** F. J. Lovas and P. H. Krupenie, *J. Phys. Chem. Ref. Data* **3**, No. 1, 245-257 (1974).

Key words: carbon monosulfide; carbon monoxide; interstellar molecules; microwave spectra; molecular parameters; radio astronomy; rotational transitions; silicon monoxide.

The available data on the microwave spectra of carbon monoxide, carbon monosulfide, and silicon monoxide are critically reviewed for information applicable to radio astronomy. Molecular data such as rotational constants, centrifugal distortion parameters, dipole moments, hyperfine coupling constants, and structure are tabulated. Observed rotational transitions are presented for all measured isotopic forms of these molecules. All of the available data has been analyzed in order to predict all rotational transitions of these molecules up to 300 GHz. Error limits have been taken from the original literature for each measured transition frequency. All predicted transition frequencies are given with estimated uncertainties which represent the 90 percent confidence limit.

**Microwave spectra of molecules of astrophysical interest. VIII. Sulfur monoxide,** E. Tiemann, *J. Phys. Chem. Ref. Data* **3**, No. 1, 259-268 (1974).

Key words: interstellar molecules; microwave spectra; molecular parameters; radio astronomy; rotational transitions; spectra; sulfur monoxide.

The available data on the microwave spectrum of sulfur monoxide (SO) is critically reviewed and tabulated. Molecular data such as rotational constants, hyperfine coupling constants, electric dipole moment, and magnetic  $g$ -factors are given. All rotational transitions up to 350 GHz for the isotopic species  $^{32}\text{S}^{16}\text{O}$ ,  $^{34}\text{S}^{16}\text{O}$ , and  $^{32}\text{S}^{18}\text{O}$  in the ground vibrational state are calculated and tabulated along with their estimated 95 percent confidence levels. The line strengths of all tabulated transitions have been determined. A bibliography of SO is given which includes results from microwave spectroscopy as well as from electron paramagnetic resonance.

**Tables of molecular vibrational frequencies. Part 8,** T. Shimanouchi, *J. Phys. Chem. Ref. Data* **3**, No. 1, 269-308 (1974).

Key words: fundamental frequencies; infrared spectra; polyatomic molecules; Raman spectra; vibrational frequencies.

The compilations to fundamental vibrational frequencies of molecules previously published in the NSRDS-NBS publication series and in this journal are here extended to 49 additional molecules. Selected values of the fundamental vibrational frequencies are given for each molecule, together with observed infrared and Raman spectral data and citations to the original literature. The selection of vibrational fundamentals has been based on careful studies of the spectral data and comprehensive normal-coordinate analyses. An estimate of the accuracy of the selected values is included. The tables provide a convenient source of information for those who require vibrational energy levels and related properties in molecular spectroscopy, thermodynamics, analytical chemistry, and other fields of physics and chemistry.

## Volume 3, No. 2

**JANAF Thermochemical Tables, 1974 supplement,** M. W. Chase, J. L. Curnutt, A. T. Hu, H. Prophet, A. N. Syverud, and L. C. Walker, *J. Phys. Chem. Ref. Data* **3**, No. 2, 311-480 (1974).

Key words: critically evaluated data; enthalpy; entropy; equilibrium constant of formation; free energy of formation;

Gibbs energy function; heat capacity; heat of formation; thermochemical tables.

The thermodynamic tabulations previously published as NSRDS-NBS-37 are extended by 154 new and revised tables. The JANAF Thermochemical Tables cover the thermodynamic properties over a wide temperature range with single phase tables for the crystal, liquid, and ideal gas state. The properties given are heat capacity, entropy, Gibbs energy function, enthalpy, enthalpy of formation, Gibbs energy of formation, and the logarithm of the equilibrium constant for formation of each compound from the elements in their standard reference states. Each tabulation lists all pertinent input data and contains a critical evaluation of the literature upon which these values are based. Literature references are given.

**High temperature properties and decomposition of inorganic salts.**

**Part 4. Oxy-salts of the halogens,** K. H. Stern, *J. Phys. Chem. Ref. Data* **3**, No. 2, 481-526 (1974).

Key words: bromates; bromites; chlorates; chlorites; critically evaluated data; iodates; iodites; perbromates; perchlorates; periodates; thermal decomposition; thermodynamic functions.

The literature dealing with the high-temperature behavior of inorganic oxygen-containing salts of chlorine, bromine and iodine has been critically reviewed. Values of  $(G^\circ_T - H^\circ_{298})/T$  of the reactants and products of the decomposition reactions were calculated and have been tabulated from 298 K up to as high a temperature as possible. Equilibrium constants and partial pressures were tabulated. Auxiliary data on phase transitions and densities have also been included. Qualitative information about the thermal decomposition of the salts is reviewed.

**Diffusion in copper and copper alloys. Part II. Copper-silver and copper-gold systems,** D. B. Butrymowicz, J. R. Manning, and M. E. Read, *J. Phys. Chem. Ref. Data* **3**, No. 2, 527-602 (1974).

Key words: alloy diffusion; copper; diffusion; electromigration; gold; grain boundary diffusion; impurity diffusion; liquid metal diffusion; silver; surface diffusion; thermomigration.

A survey, comparison, and critical analysis is presented of data compiled from the scientific literature concerning diffusion in copper-silver and copper-gold systems. Here the term "copper alloy system" is interpreted in the broadest sense. For example, the review of diffusion in the Cu-M system reports all diffusion situations which involve both copper and element M, including diffusions of Cu in M or in any binary, ternary or multicomponent alloy containing M; diffusion of M in Cu or in any alloy containing Cu; and diffusion of any element in any alloy containing both Cu and M. Topics include volume diffusion, surface diffusion, grain boundary diffusion, tracer diffusion, alloy interdiffusion, electromigration, thermomigration, strain enhanced diffusion, and diffusion in molten metals. An extensive bibliography is presented along with figures, tabular presentation of data and discussion of results.

## Volume 3, No. 3

**Microwave spectral tables. I. Diatomic molecules,** F. J. Lovas and E. Tiemann, *J. Phys. Chem. Ref. Data* **3**, No. 3, 609-770 (1974).

Key words: diatomic molecules; dipole moments; hyperfine structure; internuclear distance; molecular spectra; rotational constants; rotational spectral lines.

All of the rotational spectral lines observed and reported in the open literature for 83 diatomic molecules have been tabulated. The isotopic molecular species, assigned quantum numbers, observed frequency, estimated measurement uncertainty, and



reference are given for each transition reported. In addition to rectifying a number of misprints and errors in the literature cited, the spectral lines for approximately 20 molecules have been re-analyzed to produce a comprehensive and consistent analysis of all the data extracted from various literature sources. The derived molecular properties, such as rotational constants, hyperfine structure constants, electric dipole moments, rotational  $g$ -factors and internuclear distances are listed with one standard deviation uncertainties for all species.

**Ground levels and ionization potentials for lanthanide and actinide atoms and ions**, W. C. Martin, L. Hagan, J. Reader, and J. Sugar, *J. Phys. Chem. Ref. Data* 3, No. 3, 771-780 (1974).

Key words: actinide elements; atomic data; atomic ground levels; ionization energies; ionization potentials; lanthanide elements.

Values of the first four ionization potentials of the lanthanides ( $Z=57-71$ ) and of Hf have been compiled. All except the value for neutral Hf are based on spectroscopic data. The spectroscopic designations of the ground levels of the neutral through triply ionized atoms ( $Z=57-72$ ) are also tabulated. A similar compilation for the actinides ( $Z=89-103$ ) lists Sugar's recent values for the first ionization potentials through No ( $Z=102$ ). Accurate spectroscopic ionization potentials have been determined for only two of the actinide ions ( $\text{Ac}^+$  and  $\text{Th}^{3+}$ ). The ground-level designations for the neutral through triply ionized actinides are given where they are known or can be predicted with near certainty. A selection of references to the most complete and most recent work on the analyses of the optical spectra of the neutral through triply ionized lanthanide and actinide elements is included.

**Behavior of the elements at high pressures**, J. F. Cannon, *J. Phys. Chem. Ref. Data* 3, No. 3, 781-824 (1974).

Key words: critically evaluated data; crystal structures; elements; high pressure; melting curves; phase diagrams; polymorphism.

Data on polymorphic phase changes and variation of melting temperature of the elements with pressure have been compiled and critically evaluated. Emphasis has been placed on work done at pressures exceeding 1 kbar. Pressure-temperature phase diagrams showing first-order solid-solid phase boundaries and/or melting curves derived from the best available data are given for 58 elements. Information on the crystal structures of high-pressure polymorphs is also reviewed. Those elements that exist in the gaseous state at room temperature and pressure are not included.

## Volume 3, No. 4

**Reference wavelengths from atomic spectra in the range 15 Å to 25000 Å**, V. Kaufman and B. Edlén, *J. Phys. Chem. Ref. Data* 3, No. 4, 825-896 (1974).

Key words: optical spectra, atomic; reference wavelengths; standard wavelengths; vacuum ultraviolet.

This is a compilation of atomic lines with accurately known wavelengths covering the range from 15 Å to 25000 Å. The tables are a fairly complete record of available spectrum lines that meet the requirements for useful references with regard to wavelength accuracy and intensity. In general, wavelength uncertainties range from 0.0001 Å to 0.0002 Å. Section 1,  $\lambda > 2000$  Å, gives  $\lambda_{\text{air}}$  and  $\lambda_{\text{vac}}$  for 3341 lines belonging to thirteen different spectra of ten elements. Section 2,  $\lambda < 2000$  Å, contains 2091 lines belonging to 59 different spectra of 28 elements. The lines of section 2 are listed both by spectrum (i.e., element and ionization stage) and in a finding list arranged in order of decreasing wavelength. Detailed explanations of the data and the sources used for the compilation are included.

**Elastic properties of metals and alloys. II. Copper**, H. M. Ledbetter and E. R. Naimon, *J. Phys. Chem. Ref. Data* 3, No. 4, 897-936 (1974).

Key words: bulk modulus; compressibility; copper; elastic constants; Poisson's ratio; shear modulus; single-crystal elastic coefficients; Young's modulus.

The elastic properties of copper have been compiled and reviewed. Polycrystalline elastic constants included are: Young's modulus, the shear modulus, the bulk modulus, and Poisson's ratio. Single-crystal constants of second-, third-, and fourth-order are included. Over 200 references to the experimental literature are given. A few theoretical numbers are included. When sufficient data exist, best values are recommended together with their standard errors. Effects on the elastic constants of temperature, pressure, and mechanical (plastic) deformation are included. The Cauchy (central-force) relationships and the single-crystal-polycrystal relationship are also discussed.

**A critical review of H-atom transfer in the liquid phase: Chlorine atom, alkyl, trichloromethyl, alkoxy, and alkylperoxy radicals**, D. G. Hendry, T. Mill, L. Piszkiwicz, and J. A. Howard, *J. Phys. Chem. Ref. Data* 3, No. 4, 937-978 (1974).

Key words: chlorine atom reactions; hydrogen transfer reactions; liquid phase; organic molecules; organic radical reactions; rate constants; reference data.

This review covers hydrogen-atom transfer from carbon-hydrogen bonds in organic compounds to chlorine atom, methyl, ethyl, trichloromethyl,  $t$ -butoxy and alkylperoxy radicals in the liquid phase. Rate constant data are presented in 38 tables. Literature is covered through most of 1972. The review is divided into six sections; an introduction plus five sections each dealing with specific radicals. Hydrogen-atom transfer to chlorine atom are presented as relative rate constants. For hydrogen-atom transfer to methyl, ethyl, trichloromethyl, and  $t$ -butoxy radicals, both relative and absolute rate constants are tabulated. For alkylperoxy radicals only absolute rate constants are listed. Each absolute rate constant has a tabulated set of rate parameters where  $A$  has been assigned and  $E$  derived from the Arrhenius equation.

**The viscosity and thermal conductivity coefficients for dense gaseous and liquid argon, krypton, xenon, nitrogen, and oxygen**, H. J. M. Hanley, R. D. McCarty, and W. M. Haynes, *J. Phys. Chem. Ref. Data* 3, No. 4, 979-1018 (1974).

Key words: argon; correlation; critical data evaluation; critical point; dense gas and liquid; excess transport property functions; krypton; nitrogen; oxygen; tables; thermal conductivity coefficient; transport property; viscosity coefficient; xenon.

Data for the viscosity and thermal conductivity coefficients of argon, nitrogen, and oxygen have been critically evaluated. A functional form to represent the data has been proposed. The function is basically the same for both coefficients if the contribution of the viscosity coefficient at high densities is considered as a separate effect. The critical point enhancement in the thermal conductivity coefficient is also treated separately. Transport properties of krypton and xenon are calculated by means of the principle of corresponding states. Tables of values are presented in the range from about the triple point temperature to 500 K for pressures up to 100 MPa. Care has been taken to ensure that the calculated values are consistent with reliable equation-of-state data and also with dilute gas transport coefficients previously determined. The uncertainties of the tabulated coefficients are assessed as follows: Viscosity: argon, nitrogen, and oxygen,  $\pm 2$  percent; krypton and xenon,  $\pm 5$  percent. Thermal conductivity: argon, nitrogen, and oxygen,  $\pm 4$  percent increasing to  $\pm 15$  percent in the critical region and to 8 percent



above 200 K; krypton and xenon,  $\pm 8$  percent again increasing to  $\pm 15$  percent in the critical region. The correlation further serves

to clarify the state of the art concerning transport data and experiment and to emphasize gaps in data coverage.

### 3.5. MONOGRAPHS

Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

**Monogr. 25, Section 11. Standard x-ray diffraction powder patterns. Section 11-data for 70 substances,** H. E. Swanson, H. F. McMurdie, M. C. Morris, E. H. Evans, B. Paretzkin, J. H. de Groot, and S. J. Carmel, Nat. Bur. Stand. (U.S.), Monogr. 25-Sec. 11, 134 pages (Feb. 1974) SD Catalog No. C13.44:25/Sec. 11.

**Key words:** crystal structure; integrated intensities; lattice constants; peak intensities, powder patterns; reference intensities; standard; x-ray diffraction.

Standard x-ray diffraction patterns are presented for 70 substances. Fifty-two of these patterns represent experimental data and 18 are calculated. The experimental x-ray powder diffraction patterns were obtained with an x-ray diffractometer. All d-values were assigned Miller indices determined by comparison with computer interplanar spacings consistent with space group extinctions. The densities and lattice constants were calculated, and the refractive indices were measured whenever possible. The calculated x-ray powder diffraction patterns were computed from published crystal structure data. Both peak height and integrated intensities are reported for the calculated patterns.

**Monogr. 125. Thermocouple reference tables based on the IPTS-68,** R. L. Powell, W. J. Hall, C. H. Hyink, Jr., L. L. Sparks, G. W. Burns, M. G. Scroger, and H. H. Plumb, Nat. Bur. Stand. (U.S.), Monogr. 125, 410 pages (Mar. 1974) SD Catalog No. C13.44:125.

**Key words:** base metal alloys; noble metal alloys; temperature scale; temperature standards; thermocouples; thermometry.

Revision of the International Practical Temperature Scale requires that there be changes for all accurately tabulated thermophysical values. Revised reference data for thermocouples have been generated in a cooperative program between groups of the National Bureau of Standards in Boulder and Gaithersburg. This Monograph contains tables, analytic expressions, various approximations, and explanatory text. Only the standard letter-designated thermocouples are described: noble metal Types S, R, and B and base metal Types E, J, K, and T. Their appropriate "single-leg" or thermoelement versus Pt-67 values are also included. The new reference data reflect not only revisions in the temperature scale, but also slight changes in the materials themselves and improvements in data fitting methods. The temperature ranges vary for different types, from a low of  $-270^{\circ}\text{C}$  for Type E to a high of  $1820^{\circ}\text{C}$  for Type B. The main functions and tables are given in terms of Celsius degrees and microvolts. Tables in the appendices represent the data with less precision, in millivolts, and in degrees Fahrenheit as well as Celsius. Approximate quadratic, cubic, and quartic analytic expressions are also given for each thermocouple type in various temperature ranges. Supersedes NBS Circular 561.

**Monogr. 133. Mass and mass values,** P. E. Pontius, Nat. Bur. Stand. (U.S.), Monogr. 133, 39 pages (Jan. 1974) SD Catalog No. C13.44:133.

**Key words:** apparent mass; buoyancy corrections; mass comparison; mass value; true mass; weighing.

There are several bases for assigning mass values to weights to be used as mass standards. As a consequence a given weight may have several assigned mass values depending on the basis used. In many cases, the differences between these assigned

values, although easily detectable with precise weighing equipment, are of no practical concern. However, in some instances these differences may be crucial. The first part of this paper is a historical summary of weighing, standards, and the assignment of value; and the interfacing of mass measurements with civilization. The second part of this paper discusses in detail the methods of assigning mass values. Ways to convert from values on one basis to values on another basis are discussed. Sample problems relating to the buoyant effect of the air are presented in the appendices.

**Monogr. 138. MeV total neutron cross sections,** R. B. Schwartz, R. A. Schrack, and H. T. Heaton II, Nat. Bur. Stand. (U.S.), Monogr. 138, 160 pages (Jan. 1974) SD Catalog No. C13.44:138.

**Key words:** MeV neutrons; neutron time-of-flight; neutron total cross sections.

This report is a compilation of the MeV neutron total cross section data measured at the National Bureau of Standards over the past several years. The measurements generally span the energy interval from 0.5 to 15 or 20 MeV; data are presented in graphical form for twelve normally occurring elements, plus the separated isotopes  $^{235}\text{U}$ ,  $^{238}\text{U}$ , and  $^{239}\text{Pu}$ . An appendix is included which gives complete details of the experimental technique.

**Monogr. 140. Time and frequency: Theory and fundamentals,** B. E. Blair, Ed., Nat. Bur. Stand. (U.S.), Monogr. 140, 470 pages (May 1974) SD Catalog No. C13.44:140.

**Key words:** accuracy; Allan variance; atomic frequency standards; atomic time scales; AT(NBS); BIH; buffer gases; CCIR; clock ensembles; clocks; crystal aging; Cs frequency standard; dissemination techniques; figure of merit; flicker noise; frequency stability; frequency standards; frequency/time metrology; hydrogen maser; leap seconds; Loran-C; magnetic resonance; masers; NBS-III; NBS-5; NBS/USNO time coordination; Omega; optical pumping; precision; quartz crystal oscillators; radio T/F dissemination; Rb frequency standards; satellite T/F dissemination; short-term stability; SI Units; TAI; television T/F dissemination; thallium beam standards; time; time dispersion; time domain; time/frequency statistics; time scale algorithm; time scales; "unified standard"; URSI; USA standard time zones; UTC (NBS); UTC (USNO).

This is a tutorial Monograph describing various aspects of time and frequency (T/F). Included are chapters relating to elemental concepts of precise time and frequency; basic principles of quartz oscillators and atomic frequency standards; historical review, recent progress, and current status of atomic frequency standards; promising areas of developing future primary frequency standards; relevance of frequency standards to other areas of metrology including a unified standard concept; statistics of T/F data analysis coupled with the theory and construction of the NBS atomic time scale; an overview of T/F dissemination techniques; and the standards of T/F in the USA. This Monograph addresses both the specialist in the field as well as those desiring basic information about time and frequency. The authors trace the development and scope of T/F technology, its improvement over periods of decades, its status today, and its possible use, applications, and development in days to come.

**Monogr. 141. The measurement of lumped parameter impedance: A metrology guide,** R. N. Jones, Nat. Bur. Stand. (U.S.), Monogr. 141, 211 pages (June 1974) SD Catalog No. C13.44:141.



Key words: adapters; capacitance; capacitors; detectors; generators; impedance instruments; impedance standards; inductance; inductors; measurement methods; reactance; resistance; resistor; standards.

The measurement of two-terminal impedance in the 30 kHz to 300 MHz range involves a variety of different methods including null, resonance, active and comparison. Each method is represented by a number of instruments having specific capabilities, strengths, and weaknesses. This metrology guide is intended to assist the scientist who is not intimately familiar with impedance measurement, in the selection and use of the best instrument for a particular requirement. Information is included on range and accuracy capabilities as well as availability and ease of operation. In addition to providing help in the selection of the appropriate instrument, there are operating tips which enhance accuracy, criteria for choosing standards, means for extending normal measurement range of an instrument, a discussion on generators and detectors, and a section on the evaluation and use of adapters. Finally, an extensive bibliography is included to assist in pursuing a particular problem beyond the depth of the guide.

Monogr. 142. **The measurement of noise performance factors: A metrology guide**, M. G. Arthur, Nat. Bur. Stand. (U.S.), Monogr. 142, 202 pages (June 1974) SD Catalog No. C13.44:142.

Key words: effective input noise temperature; measurement errors; noise factor; noise measurements; noise performance factors; noise temperature; Y-factor measurements.

This metrology guide provides the basis for critical comparisons among seven measurement techniques for average noise factor and effective input noise temperature. The techniques that are described, discussed, and analyzed include the (1) Y-Factor, (2) 3-dB, (3) Automatic, (4) Gain Control, (5) CW, (6) Tangential, and (7) Comparison Techniques. The analyses yield working equations and error equations by which accuracy capabilities are compared. Each technique is also analyzed for (a) frequency range for best measurement results,

(b) special instrumentation requirements, (c) speed and convenience, (d) operator skill required, and (e) special measurement problems. General instrumentation requirements and practical measurement problems are discussed for the benefit of the nonexpert metrologist. Worked examples illustrate the principles involved in applying the working and error equations. An extensive bibliography and suggested reading list aid the metrologist to locate additional material on these measurements. Taken altogether, this guide will be helpful in selecting the best measurement technique for any of a wide range of operational requirements and, once the technique is selected, it will be of further benefit in helping the metrologist identify where his efforts should be placed to derive the greatest efficiency and accuracy from his measurement system.

Monogr. 146. **The theory of the optical wedge beam splitter**, Y. Beers, Nat. Bur. Stand. (U.S.), Monogr. 146, 31 pages (Oct. 1974) SD Catalog No. C13.44:146.

Key words: optical attenuation; optical beam splitter.

An optical wedge beam splitter consists of a prism of transparent material with a very small apex angle, usually about one degree. If a pencil beam of radiation is incident upon it, a portion enters the material and undergoes a series of reflections at the surfaces. At each reflection a refracted beam emerges from the material. This paper gives the basic theory for computing the ratio of the intensity of the incident beam to the intensity of any selected emerging beam and also for computing the direction of the emerging beam, assuming that the wedge angle, index of refraction, angle of incidence, and number of reflections are known.

The paper also gives the results of numerical calculations based upon this theory for sample situations which are of interest. It is shown that polarization effects can be minimized by the use of a small wedge angle and by the proper selection of the angle of incidence. In particular, it is shown that it is possible by the use of four reflections and a wedge angle of one degree to obtain attenuation factors of about 400,000 (56 db), and that the effect of changes in polarization on the attenuation factor can be held down to about one percent.

### 3.6. HANDBOOKS

Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

**H113. CODASYL data description language.** *Journal of Development*, June 1973, Nat. Bur. Stand. (U.S.), Handb. 113, 155 pages (Jan. 1974) SD Catalog No. C13.6/2:113.

Key words: COBOL; CODASYL; data base administration; data base management; data base task group; data description language.

This *Journal of Development* reports the work of the CODASYL Data Description Language Committee. The Committee was assigned the tasks of establishing "ways to aid the functions of data administration and systems administration." The Committee's charter included, "the provision of specifications for the declarations required to establish and maintain data base structures." As a step towards this purpose, the *Journal* contains three sections which treat the Background and History of the Data Description Language Committee, Major Concepts, and the specifications of the Data Description Language. The Committee based its work, in part, on the 1971 report of the Data Base Task Group Report.

The approved Data Description Language specifications contain the syntax and semantic rules that permit the description of the structure and contents of a data base in a language independent of, but common to, many other high level programming lan-

guages. The language specifications will have a significant impact on the development of functionally compatible data base management systems and will increase the portability of programs between different computer systems.

Though not part of the approved language specifications, the presentation of the major concepts will help in the understanding of the specifications. Similarly, the background and history information will help explain the evolutionary growth of the Data Description Language.

**H115. Energy Conservation Program Guide for Industry and Commerce (EPIC),** R. R. Gatts, R. G. Massey, and J. C. Robertson, Nat. Bur. Stand. (U.S.), Handb. 115, 212 pages (Sept. 1974) SD Catalog No. C13.11:115.

Key words: energy conservation; energy conservation guide; energy conservation opportunities; energy conservation program; industrial energy conservation.

The Energy Conservation Program Guide for Industry and Commerce (EPIC) is a guide to assist business and industry to establish an on-going conservation program. EPIC outlines the steps in an energy conservation program and suggests specific ways to reduce energy use in manufacturing and commercial businesses. EPIC focuses on two aspects of energy conservation: (1) The key steps in an implementation plan for an energy conservation plan; (2) Energy Conservation opportunities which have been identified by industry.



### 3.7. SPECIAL PUBLICATIONS

Include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

SP236, 1974 Edition. **NBS frequency and time broadcast services. Radio stations WWV, WWVH, WWVB, and WWVL**, P. P. Viezbicke, Ed., (Supersedes NBS Special Publication 236, 1973 and previous editions) Nat. Bur. Stand. (U.S.), Spec. Publ. 236, 1974 Edition, 19 pages (Mar. 1974) SD Catalog No. C13.10:236, 1974 Ed.

Key words: broadcast of standard frequencies; high frequency; low frequency; standard frequencies; time signals; very low frequency.

Detailed descriptions are given of the technical services provided by the National Bureau of Standards radio stations WWV, WWVH, WWVB and WWVL. These services are: 1. Standard radio frequencies; 2. Standard audio frequencies; 3. Standard musical pitch; 4. Standard time intervals; 5. Time signals; 6. UTI corrections; and 7. Official announcements. In order to provide users with the best possible services, occasional changes in broadcasting schedules are required. This publication shows the schedules in effect on January 1, 1974. Annual revisions will be made. Current data relating to standard frequencies and time signals are available monthly in the Time and Frequency Services Bulletin. Advance notices of changes occurring between revisions will be sent to users of NBS broadcast services who request such notice on the basis of need. Supersedes NBS Special Publication 236, 1973 and previous editions.

SP260-47. **Standard reference materials: Electrical resistivity of electrolytic iron, SRM 797, and austenitic stainless steel, SRM 798, from 5 to 280 K**, J. G. Hust, Nat. Bur. Stand. (U.S.), Spec. Publ. 260-47, 20 pages (Feb. 1974) SD Catalog No. C13.10:260-47.

Key words: austenitic stainless steel; cryogenics; electrical resistivity; electrolytic iron; Lorenz ratio; standard reference material.

Electrical resistivity data are presented for characterized electrolytic iron, SRM 797, and austenitic stainless steel, SRM 798, at temperatures from 5 to 280 K. Resistivities at ice and liquid helium temperatures were determined for 22 randomly selected iron specimens and the same number of steel specimens. These data indicate that the effect of material variability is about 1 percent for each of these SRM's.

SP260-48. **Standard Reference Materials: Description and use of precision thermometers for the clinical laboratory, SRM 933 and SRM 934**, B. W. Mangum and J. A. Wise, Nat. Bur. Stand. (U.S.), Spec. Publ. 260-48, 23 pages (May 1974) SD Catalog No. C13.10:260-48.

Key words: clinical laboratory; enzymology; health care; liquid-in-glass thermometers; standard reference material; SRM 933; SRM 934; thermometers.

Because of the high sensitivity to temperature of many facets of the clinical laboratory, e.g., in enzyme reactions and in pH and blood gas analysis, there is a need for accurate temperature measurements and its control. In order to help satisfy these needs and to aid in getting a usable and accurate temperature scale into the clinical laboratory, the National Bureau of Standards has developed SRM 933 and SRM 934. These are precision thermometers, which are calibrated at 0, 25, 30, and 37 °C and their

description, their calibration, and the procedures for their proper usage are discussed.

SP260-49. **Standard reference materials: Calibrated glass standards for fission track use**, B. S. Carpenter and G. M. Reimer, Nat. Bur. Stand. (U.S.), Spec. Publ. 260-49, 25 pages (Nov. 1974) SD Catalog No. C13.10:260-49.

Key words: fission tracks; flux monitors; glass standards; standard reference material; thermal neutron irradiation; uranium.

Four glasses of different uranium concentrations were prepared and certified by the National Bureau of Standards as standards for use as neutron monitors to aid fission track studies. These Standard Reference Materials (SRM) and their uranium concentrations are: SRM 941 (461 ppm), SRM 962 (37.4 ppm), SRM 963 (0.823 ppm), and SRM 964 (0.0721 ppm). These glass wafers were irradiated in the National Bureau of Standards Reactor and the neutron flux was monitored using copper and gold foils.

SP305. Supplement 5. **Publications of the National Bureau of Standards 1973 catalog. A compilation of abstracts and key word and author indexes**, B. L. Oberholtzer, Ed., Nat. Bur. Stand. (U.S.), Spec. Publ. 305 Suppl. 5, 349 pages (July 1974) SD Catalog No. C13.10:305.

Key words: abstracts, NBS publications; key words; publications.

This supplement to Special Publication 305 Supplements 1, 2, 3, and 4 of the National Bureau of Standards lists the publications of the Bureau issued between January 1, 1973 and December 31, 1973. It includes an abstract of each publication (plus some earlier papers omitted from Special Publication 305 Supplement 3), key-word and author indexes; and general information and instructions about NBS publications.

Miscellaneous Publication 240 (covering the period July 1, 1957 through June 30, 1960) and its supplement (covering the period July 1, 1960 through June 30, 1966), Special Publication 305 (covering the period July 1966 through December 1967) and Special Publication 305 Supplement 1 (covering the period 1968-1969), Special Publication 305 Supplement 2 (covering the period 1970), Special Publication 305 Supplement 3 (covering the period 1971), and Special Publication 305 Supplement 4 (covering the period 1972) remain in effect. Two earlier lists, Circular 460 (Publications of the National Bureau of Standards, 1901 to June 1947) and its supplement (Supplementary List of Publications of the National Bureau of Standards, July 1, 1947 to June 30, 1957) are also still in effect. To accompany National Bureau of Standards Special Publication 305; and its Supplements 1, 2, 3, and 4.

SP366. Supplement 1. **Bibliography on atomic line shapes and shifts (April 1972 through June 1973)**, J. R. Fuhr, L. J. Roszman, and W. L. Wiese, Nat. Bur. Stand. (U.S.), Spec. Publ. 366 Suppl. 1, 73 pages (Jan. 1974) SD Catalog No. C13.10:366, Suppl. 1.

Key words: atomic; instrumental broadening; line shapes; line shifts; pressure broadening; resonance broadening; Stark broadening; Van der Waals broadening.

This is the first supplement to the NBS Special Publication 366, "Bibliography on Atomic Line Shapes and Shifts (1889 through March 1972)." It contains about 350 references and covers the literature from April 1972 through June 1973. The



bibliography contains five major parts: (1) All general interest papers are cataloged according to the broadening mechanisms (and, further, according to special topics under several of the mechanisms) and as to whether the work is a general theory, a general review, a table of profiles or parameters, a comment on existing work, a study of general experimental measurement techniques, or an experimental effort of general importance. Also included are selected papers on important applications of line broadening and on miscellaneous topics relating to atomic spectral line shapes and shifts. (2) In Part 2, all papers containing numerical data are ordered as to element, ionization stage, broadening mechanism (in the case of foreign gas broadening the perturbing species are listed), and it is indicated whether the data are experimentally or theoretically derived. (3) While in the two preceding parts of the bibliography the references are listed for brevity by identification numbers only, in Part 3 all references are listed completely by journal, authors, and title and are arranged chronologically and alphabetically within each year according to the principal author. (4) This section contains a list of all authors and their papers. (5) A final section provides corrections or additions to our first bibliography.

**SP369. Soft x-ray emission spectra of metallic solids: Critical review of selected systems and annotated spectral index**, A. J. McAlister, R. C. Dobbyn, J. R. Cuthill, and M. L. Williams, *Nat. Bur. Stand. (U.S.), Spec. Publ. 369*, 176 pages (Jan. 1974) SD Catalog No. C13.10:369.

Key words: alloys; critical review; emission spectra; inter-metallic compounds; metals; soft x ray; spectra.

Theory and experimental practice in the field of soft x-ray emission from metallic solids are briefly reviewed, and measurements on a number of systems are critically evaluated and compared with the results of other techniques and theory, with a view to establishing the pertinence of the soft x-ray measurements and indicating specific guidelines for further enhancing their value. In addition, an exhaustive annotated index of measured spectra is provided. Supersedes NBS Monograph 52 in part, for emission spectra only.

**SP382. Hydraulic research in the United States and Canada, 1972**, G. Kulin and P. H. Gurewitz, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 382*, 340 pages (Jan. 1974) SD Catalog No. C13.10:382.

Key words: fluid mechanics; hydraulic engineering; hydraulic research; hydraulics; hydrodynamics; model studies; research summaries.

Current and recently concluded research projects in hydraulics and hydrodynamics for the years 1971-1972 are summarized. Projects from more than 250 university, industrial, state and federal government laboratories in the United States and Canada are reported.

**SP388. The public need and the role of the inventor.** Proceedings of a Conference held in Monterey, Calif., June 11-14, 1973, F. Essers and J. Rabinow, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 388*, 215 pages (May 1974) SD Catalog No. C13.10:388.

Key words: antitrust doctrine; employed inventors; entrepreneurship; innovation; invention; needs of society; new enterprises; Patent Office; patent system; technological policy making; technology.

This book presents the proceedings of the Conference on the Public Need and the Role of the Inventor, held at Monterey, Calif., on June 11-14, 1973. The conference, based on a recommendation of the National Inventors Council, was sponsored by the Office of Invention and Innovation, Institute for Applied Technology, under a grant from the Experimental Technology Incentives Program, NBS. The purpose of the conference was to study the climate for invention and how to make it one in which

America's inventors can flourish for the common good. Eighteen invited papers were presented. In addition, the proceedings includes statements from the chairmen of the three sessions: Charles S. Draper, Jacob Rabinow, and Myron Coler. The proceedings are divided into three sessions with an edited version of the floor discussions following the papers. Following the presentation of papers, the participants of the conference separated into six workshop panels. Their recommendations are presented at the end of this volume. *These proceedings include the following papers (indented):*

**Inventions, innovations, and incentives**, Betsy Ancker-Johnson, *SP388*, pp. 5-6 (May 1974).

Key words: government patent policy; government R. & D.; technology enhancement efforts; technological innovation; technology transfer programs.

The Government has a responsibility to transfer the results of its research and development activities to wider use in the private sector. Last year, in the President's Science and Technology Message, and this year, in his budget, a strategic approach to technology was adopted as a national policy. The strategy includes increased funding, new emphasis on critical problems of special, national concern, and an effort to provide incentives to inventors, entrepreneurs, and research managers. The Department of Commerce is taking steps to promote actively the licensing of Government-owned patents, and the Experimental Technology Incentives Program in the National Bureau of Standards is asking such questions as "What cost-effective Federal actions can be taken to facilitate the commercialization of the technical inventions of the individual and small R. & D. firms?"

**An economist looks at the patent system**, R. D. Tollison, *SP388*, pp. 11-14 (May 1974).

Key words: economic tradeoffs; monopolies; new information; patent reform; patent system.

This talk sketches the way an economist might view the tradeoffs involved in the social institution of a patent system. If the output that a patent is designed to protect can be loosely labeled as "information," then there will always be a tension between the need for patents to stimulate the production of new information and placing a short-run monopoly price on goods that, once produced, are inherently non-rival in consumption. A patent system is probably a socially efficient way to make this tradeoff, although the fact that societies impose different standards and procedures in the patent process suggests that study and discussion of patent reform may be worthwhile.

**Trends in technological policy making**, D. V. De Simone, *SP388*, pp. 17-20 (May 1974).

Key words: experimental incentives programs; Federal incentives; technological policy making; technology assessment program.

Federal programs and policies contribute to technological advances in numerous ways. Many Federal incentives for technological innovation have been proposed over the years, but none has been put into effect. We need to develop a better basis for choosing courses of action.

Three Federal programs recently begun are aimed at this deficiency: the systematic assessment of the state of industrial technology by the Department of Commerce, a study on the barriers to technological innovation by NSF, and the experimental incentives programs being conducted by NSF and NBS. These are small-scale pilot projects, but the experiments and studies will help us understand more about the factors influencing technological advance. As a result, decision makers will be better equipped to determine what



should be the nature and extent of Federal encouragement of private investment in technological innovation.

**New enterprise generation**, R. S. Morse, *SP388*, pp. 23-28 (May 1974).

Key words: entrepreneurship; environment for innovation; government policy for innovation; industry R. & D.; new enterprises; university R. & D.

The national environment for innovations is examined: in government, industry, the university, and the public.

The administration is concerned for the environment of science and technology, but centralized leadership and responsibility for long-range analysis and planning are absent. New rules and policies, or new legislation by Congress are needed.

Industry has been trying new methods in the management of R. & D., both in establishing centers for entrepreneurship within the company, and providing venture capital to acquire new technology outside the company. The key to success in these enterprises is the entrepreneur who can judge the market and bring a new product into public use.

Universities should study the mechanisms that industry is using; there is need for research in these areas, and a need for a coupling of effort between the university and the industrial community. The university can also play an important role in teaching entrepreneurship.

The President should delegate authority either in the Executive Office or in the Department of Commerce to review the problems of invention, innovation, and entrepreneurship for the generation of new enterprises. New approaches should be tried to expedite the public use of technology and a closer relationship among government, industry, and the university.

**Inventor-entrepreneurship and national priorities**, N. S. Kapany, *SP388*, pp. 31-36 (May 1974).

Key words: business management; inventor-entrepreneur; national priorities; national problems; technological innovation.

Because he is capable in science, invention, management and business, the inventor-entrepreneur has a high potential for solving some of the urgent problems of mankind today.

The attributes of the inventor and of the entrepreneur are briefly examined: the inventor-entrepreneur combines these talents in a bold, imaginative way.

Although some national problems are of such a nature that they must be solved by massive, large-scale interdisciplinary effort, there are still many high-priority areas that can be attacked by the inventor-entrepreneur.

The optimum climate for nurturing his efforts must include: a strong technological and industrial base; a free-enterprise economic system; a healthy reception by the financial community and a sympathetic public attitude; and, a cooperative, benevolent government attitude.

The inventor-entrepreneur is a pioneer—a champion of innovation—and as such, he deserves attention, support, and a chance to share the responsibility for solving the problems of society today.

**Invention and innovation in the university**, J. Adams, *SP388*, pp. 37-43 (May 1974).

Key words: academic risk; business-Government-university relationship; faculty risk; time constraints; university entrepreneurial activities.

Universities are not fulfilling their potential as a source of public need-oriented invention and innovation. Their potential is inhibited by three constraints: risk, time, and business.

There is an academic risk to the student in undertaking projects where the outcome must be uncertain. The risk to

the faculty lies in the fact that the academic rating procedure treats entrepreneurial activities as unusual and academic publication as usual.

Time is another constraint: there is insufficient time in the academic year to develop a product and market it.

The business constraint is a lack of knowledge as to how ideas could be carried to reality with a just division of the compensation among the students, faculty, university, Government, and commercial business interests involved.

Government funding might help to solve the risk and time constraints by forming peer groups and allowing employment of long-term professional support.

People in the educational community would appreciate help on solving the business-Government-university relationship problems. Frameworks must be found and publicized in which universities can put their intellectual resources to work in a more applied way and gain reasonable financial and intellectual rewards.

**The invention of the transistor—"an example of creative-failure methodology"**, W. Shockley, *SP388*, pp. 47-88 (May 1974).

Key words: creative-failure methodology; invention of transistor; junction transistor; patents; semiconductor amplifiers; will-to-think.

Presents a general historical perspective on the invention of the transistor, from the standpoint of the patents issued and the men involved in the inventions.

Five applications for patents on transistor devices were filed prior to the first public announcement of the transistor on June 30, 1948. The development of the essential inventive ideas for these five patents is described.

Several attempts to make semiconductor amplifiers failed. These failures were used creatively by the team involved—an example of effective research, of which one of the principal elements is the "will to think." The day-to-day development of important ideas and the interaction between them are presented.

The story is continued through the invention and realization of the junction transistor.

**Antitrust doctrine v. the individual inventor: Friend or foe?**, J. C. Stedman, *SP388*, pp. 93-98 (May 1974).

Key words: antitrust; Hart proposal; inventors; patent licenses; patents; Scott proposal.

The perennial conflict between antitrust and patents is currently reflected in the Scott (Patent Bar) and Hart proposals pending before the Senate. The Scott proposal would apply a "rule of reason," giving a patentee considerable freedom in imposing various restrictions upon licensees. The Hart proposal would apply a "reasonably ancillary" test, narrowly circumscribing the patentee's freedom in this respect. The question is: which is more advantageous to the inventor, independent or employed? Restrictions in patent licenses, while they may enable the patentee to maximize his return from the invention, may at the same time provide protection from competition and thus lessen the competitive fears and hopes of competitive advantage that provide the main economic force underlying inventive activity. Thus, paradoxically, the short-range advantages of restrictive licensing may operate long-range to the detriment of the inventor. Deeper research into the subject is urgently needed, but tentatively one may suggest that enactment of a law enlarging a patentee's freedom to impose licensing restrictions may prove, in the long run, advantageous to institutions that seek to minimize the forces of competition (including competition in research and innovation), but disadvantageous to small concerns and individual inventors, independent or employed, whose welfare depends upon competitive achievement and innovative activity.



**The inventor in a changing world of patents**, A. R. Whale, *SP388*, pp. 103-110 (May 1974).

Key words: adversary proceedings; antitrust; deferred examination; independent Patent Office; innovation; inventor; patent system; useful arts.

It's time we overcome our collective hardening of the attitudes about changes in the patent system. The simple choice is whether the design of change will pass by default to those in the courts or Congress who march to different drummers, or whether those who use and understand the system will meet the challenge of change.

The patent system faces an identity crisis. Three positive approaches would help set thinking straight:

1. Emphasize the patent system's effectiveness in areas of its intended operation in the useful arts.

2. Foster understanding of the interdependence of invention and innovation in making the patent system work in the public interest.

3. Work for a no-fault divorce between patents and antitrust to rectify the subservient status now assigned to patents.

At the same time, we should move to reconstruct the patent system rather than repair it. Recognizing that the concept of patents remains sound, we should give consideration to carefully circumscribed adversary proceedings made practicable by deferred examination and maintenance fees and administered by an independent Patent Office. Thorough discussion of the possibilities and pitfalls of these approaches should lead to a patent system of increased vigor and the restoration of confidence in the patenting process without distress to the substantive aspects we seek to preserve.

**The role of the patent office in the process of invention and innovation**, E. J. Brenner, *SP388*, pp. 111-115 (May 1974).

Key words: advisers to inventors; deferred examinations; innovation; invention; mechanized searching; patent litigation; Patent Office; patent system reform; petty patents; satellite research centers.

Examines how well the U.S. Patent Office is doing its job now, and presents some suggestions that might enable it to do a better job in the future.

Within the financial limitations under which it must operate, the Patent Office performs an efficient screening operation, rather than a validity proceeding, which would take far more time and money.

Two general suggestions are given for future improvement: first, that an Assistant Secretary for Invention, Innovation, and Intellectual Property be appointed in the Department of Commerce, to serve as a focal point for these activities; and secondly, that a systems analysis approach be taken to weigh the merits of various ideas for reforming the patent system.

Specific suggestions are also made for consideration: adoption of deferred or selective examination; a system of petty patents; a greater role for the Patent Office in litigation; continued efforts to improve mechanized searching; the institution of satellite search centers and a system of advisers to inventors; and a review of the patent system to eliminate some of the technicalities that may invalidate patents.

**United States patent system: Fraud on the inventor and the public (and what can be done about it)**, I. Kayton, *SP388*, pp. 119-126 (May 1974).

Key words: inventor; monopoly; patent system; property rights; validity of patents.

The inventor is the creator of progress, and our main hope to solve most of society's problems. In order for him to be

motivated to continue inventing, he needs to have his property rights protected. By and large, the United States patent system no longer affords the protection.

There are some Federal circuits where, because of the rules of law enunciated by the United States Court of Appeals, a patent cannot be held valid, irrespective of the merit of the invention.

The law of expected return dictates which patents get litigated—there's no such thing as a *per se* good patent. The reason is the legally outrageous proposition which has been imposed on the public, the bar, and the bench, either fraudulently, through arrant ignorance or simple misconception, that all patents are monopolies. Monopolies are bad—therefore, patents are bad.

The truth is that practically no patents are monopolies. Patents are property—and where there is competition, either by product alternatives or by licensing, you cannot control price and you do not control a relevant market and you do not have a monopoly.

A revision of the patent statute is suggested which would reverse the alienation of the small inventor from the patent system and restore the system to its earlier effectiveness in promoting the useful arts.

**NBS and the inventive process**, R. W. Roberts, *SP388*, pp. 131-135 (May 1974).

Key words: Experimental Technology Incentives Program; inventors; National Bureau of Standards; Office of Invention and Innovation; technological innovation.

If we are to compete for international markets, we need more and better science, and we need a continuing supply of marketable inventions. The role of the inventor at the National Bureau of Standards, and the services offered to the outside inventor by the Bureau, are described. The aims of a major new NBS effort—the Experimental Technology Incentives Program—are explained, and suggestions are requested for additional experiments that ETIP could perform.

**The inventive process—where does it need stimulation?**, W. B. McLean, *SP388*, pp. 139-142 (May 1974).

Key words: government help to innovation; government ownership of patents; innovation; inventor; patent system.

The patent system is crucial for the development of our national economy. Its influence is exerted by providing a period in which risk capital needed for development can realize a return through production. The inventor and his returns are only incidental to this process.

Many areas of new development exist where the returns to the economy would be great but the Government is the only organization capable of starting the development. These include: (1) Satellite communications; (2) Two-way cable TV; (3) Floating cities; (4) Undersea cities and oil and mining operations; (5) Submarine tankers. Government ownership of patents is inconsistent with the purpose for which the patent system was created because it has no reasonable means to grant exclusive licenses.

**The employed inventor and the corporation**, C. E. Anagnostopoulos, *SP388*, pp. 145-149 (May 1974).

Key words: corporation; employed inventor; innovation; invention; research director; technological entrepreneur.

The idea that the goals of the employed inventor conflict with those of the corporation is an outmoded fallacy. The creative challenges of the modern corporation are totally compatible with the creative drives of the employed inventor. Through invention, he discovers new and useful solutions to problems. Through innovation, the corporation commercializes such technical advances. Corporate growth



and profitability today depend upon planned and systematic innovation.

Such innovation requires not only the technical certainty of a useful invention, but also an evaluation and reduction of its commercial risks by such criteria as corporate fit, market timing and potential business volume. The presumed conflict between the employed inventor and the corporation is at this interface between his empirical proof that his invention works and the corporation's pragmatic assessment of it as a business risk.

Actually, this point of stress is a constructive interfacial tension that can be most productive if kept in dynamic equilibrium. This is a task for a middleman who, more than a research director, is a technological entrepreneur; technically well-grounded and with a full grasp of corporate objectives. His role: motivating interpreter to both the employed inventor and the corporation, having the respect and confidence of each.

**The institutions and environment for inventors in IBM, D. DeWitt, *SP388*, pp. 153-156 (May 1974).**

Key words: environment for innovation; IBM Fellow; institutions for inventors; inventors; rewards for inventors.

IBM seeks to create and maintain in its laboratories an environment conducive to innovation. Inventors are aided by instruction in patent practice, prompt and competent evaluation of submissions, and the help of experienced patent attorneys. Innovation is encouraged by a system of recognition and rewards for patents issued and outstanding technical contributions.

The IBM Fellow appointment is an attractive long-range objective for inventive people: it is a lifetime appointment which gives the Fellow freedom to do innovative work of his own choosing, with appropriate support.

The IBM institutions for encouragement of innovations were introduced about 10 years ago, and have been modified from time to time. They are still being evaluated, but the results have been largely favorable.

**The role of the inventor in an industrial laboratory, J. A. Rajchman, *SP388*, pp. 159-164 (May 1974).**

Key words: antitechnical crisis; industrial laboratory; industrial research; scientist-inventor; technical innovations.

The industrial research laboratories of large corporations have been a great success; as one of the main mechanisms for harnessing the process of innovation they have benefited their sponsors, society and the scientist-inventor. To the imaginatively inclined technical man they have provided a living and a place in society. Furthermore, a seasoned laboratory provides broad options to the individual to pursue his ambitions according to his talents, as it exploits with subtlety the fact that it is at the crossroads between science, production and the market place and therefore finds good value in individual genius, cooperative work as well as managerial initiative. To a great many technical men the industrial laboratory offers the proper arena for undertaking technical innovations. The personal experiences of the author, at RCA Laboratories, as individual contributor as well as manager, illustrate the point.

The present antitechnical crisis has various symptoms. In the industrial laboratory, budgets are no longer lush, there are problems with non-growing staff, and there is a shift from science to engineering that is accompanied by short range expectations. More alarming are symptoms of disillusionment elsewhere, mostly with the young, among whom many fewer aspire to science and technology. As one possible remedy a plea is made for society to show far greater appreciation and respect toward technical innovators in addition to bestowing them with essential material awards.

**Systems to stimulate employee-inventions in Europe, F. Neumeyer, *SP388*, pp. 167-174 (May 1974).**

Key words: awards to inventors; employee-inventors; European incentive systems for inventors; Japanese incentive systems for inventors; legal employee-inventor incentive systems; Soviet Union incentive systems for inventors.

An analysis is made of systems, in Europe and elsewhere, to stimulate employee-inventions by legal and voluntary incentive systems, which are part of the overall pattern of the economic and political regime prevailing in a country. The following countries are examined: the Soviet Union, Sweden, Denmark, Norway, Finland, Austria, Holland, Germany, Japan, Great Britain, and Canada. The legal incentive systems in these countries include tangible and intangible rewards. Tangible rewards are: extra compensation, tax relief, standard cash payment, or release of the rights of invention. Intangible rewards include the right to be mentioned in the patent, and honorary titles conferred on the inventor. The objects of these measures are human beings; we need their imagination; and generosity and justice to them will be repaid by them manifold.

**European perspective of the inventor ecology, H. Romanus, *SP388*, pp. 175-182 (May 1974).**

Key words: European efforts to aid inventors; inventor; inventor ecology; Swedish Board for Technical Development.

Examines the hazards and impediments to inventors, and the methods that some states—in particular, Sweden—are taking to remove these impediments.

Inventors need technical help to develop their ideas, financial help, advice on patenting, and aid in selling their ideas to industry. Having grown from a small beginning in the 1930's, the Swedish Board for Technical Development now has the know-how and resources to perform these services for inventors who they consider are worthy of help. The Board also evaluates proposed legislation affecting inventors, and studies the climate of invention activities.

The practices of the Swedish Board for Technical Development are being followed in other European countries in an effort to support the first link in the innovation chain—invention.

**The inventor—his motivations and society, S. Ruben, *SP388*, pp. 195-197 (May 1974).**

**SP390. Index of international standards, S. J. Chumas, Ed., Nat. Bur. Stand. (U.S.), Spec. Publ. 390, 222 pages (Mar. 1974) SD Catalog No. C13.10:390.**

Key words: analyses; International Commission on Rules for the Approval of Electrical Equipment; International Electrotechnical Commission; International Organization for Standardization; International Organization of Legal Metrology; International Special Committee on Radio Interference; recommendations; specifications; standards; test methods.

This computer-produced Index, based on the Key-Word-In-Context (KWIC) system, contains over 2,700 standards titles of the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), the International Commission on Rules for the Approval of Electrical Equipment (CEE), the International Special Committee on Radio Interference (CISPR), and the International Organization of Legal Metrology (OIML).

**SP391. Report of the 58th National Conference on Weights and Measures 1973, S. J. Wilson and R. N. Smith, Eds., Nat. Bur. Stand. (U.S.), Spec. Publ. 391, 208 pages (May 1974) SD Catalog No. C13.10:391.**



**Key words:** administration; automated checkstand systems; Conference; consumers; laws and regulations; metrication; open dating; procedures; technical requirements; technology; universal product coding; weights and measures.

This is a report of the proceedings (edited) of the Fifty-Eighth National Conference of Weights and Measures, sponsored by the National Bureau of Standards, held in Minneapolis, Minn., July 22-27, 1973, and attended by state, county, and city weights and measures officials, the Federal Government, business, industry, and consumer organizations. *These proceedings include the following papers (indented):*

**Measures for progress**, G. L. Johnson, *SP391*, pp. 1-3 (May 1974).

**Universal product code in the grocery industry:**

**Effect of UPC on supermarket operations and equipment**, R. H. Sloat, *SP391*, pp. 27-31 (May 1974).

**Computerized checkstand weighing system**, W. N. Shannon, *SP391*, pp. 32-36 (May 1974).

**Digital designs in weighing systems:**

**Applications in retail trade**, R. O. Bradley, *SP391*, pp. 36-40 (May 1974).

**Large capacity scale designs**, T. G. Soper, *SP391*, pp. 41-48 (May 1974).

**Dynamic weighing in the railroad industry**, E. W. Hodgkins, *SP391*, pp. 49-53 (May 1974).

**Gasoline measurement and marketing:**

**Changing systems and designs**, W. F. Gerdorn, *SP391*, pp. 55-57 (May 1974).

**Electronic components and applications**, R. J. McCrory, *SP391*, pp. 58-64 (May 1974).

**Weighting on the mail**, A. Smith, *SP391*, pp. 64-75 (May 1974).

**Net quantity — directions and determinations:**

**Viewpoint on net weight variations**, G. M. Burditt, *SP391*, pp. 75-82 (May 1974).

**Status of Handbook 67 revision**, E. A. Vadelund, *SP391*, pp. 83-90 (May 1974).

**Management assistance for weights and measures progress:**

**MIS analyses and concept development**, E. G. Neigut, *SP391*, pp. 91-97 (May 1974).

**Measuring inaccuracy's economic distortion**, S. W. Stiefel, *SP391*, pp. 97-107 (May 1974).

**New approach in weights and measures operations:**

**Pilot program**, W. H. Korth, *SP391*, pp. 108-114 (May 1974).

**Development of Dallas Department of Consumer Affairs**, C. H. Vincent, *SP391*, pp. 115-121 (May 1974).

**Consumer protection in Minnesota**, S. Keefe, *SP391*, pp. 122-132 (May 1974).

**SP392. Vibrationally excited hydrogen halides: A bibliography on chemical kinetics of chemiexcitation and energy transfer processes (1958 through 1973)**, F. Westley, Nat. Bur. Stand. (U.S.), Spec. Publ. 392, 81 pages (Apr. 1974) SD Catalog No. C13.10:392.

**Key words:** bibliography; chemical kinetics; chemiexcitation; gas phase; halogens; hydrogen; hydrogen halides; laser; quenching; vibrational energy transfer.

A bibliography, a reaction oriented list of references, is provided for published papers and reports containing rate data for reactions of halogen atoms with hydrogen-containing compounds, or of H (D, or T) atoms with halogen-containing compounds to form vibrationally chemiexcited hydrogen halides. The reactions for vibroexcitation of hydrogen halides through unimolecular or photochemical elimination, as well as the processes for vibrational energy transfer between hydrogen halides and various second bodies are also included. In addition, four lists of theoretical papers and a list of critical reviews and bibliographies are provided. Over 300 papers covering 50 types of reactions are listed. The period covered extends from 1958 through 1973.

**SP393. Colorimetry and spectrophotometry: A bibliography of NBS publications January 1906 through January 1973**, K. L. Kelly, Nat. Bur. Stand. (U.S.), Spec. Publ. 393, 54 pages (Apr. 1974) SD Catalog No. C13.10:393.

**Key words:** bibliography; color; color codes; colorimetry; color measurement; spectrophotometry; vision.

This bibliography of publications will serve as the key to the large amount of research into color measurement and specification, and color vision carried out by the staff of the National Bureau of Standards (NBS) in colorimetry and spectrophotometry. These 623 publications appeared in NBS publications and outside scientific and technical journals between January 1906 and January 1973. This material has been in constant demand by Bureau members as well as by outside individuals and organizations. The practical value of this wealth of information lies in its ready accessibility to the scientific and technical fraternity by title, by key words or by author, in the Library of Congress and in depository libraries such as large public and university libraries. A short organizational chronology of the colorimetry and spectrophotometry program is included.

**SP394. MFPG. The role of cavitation in mechanical failures**, Proceedings of the 19th Meeting of the Mechanical Failures Prevention Group, held at the National Bureau of Standards, Oct. 31, Nov. 1 and 2, 1973, Boulder, Colo. 80302, T. R. Shives and W. A. Willard, Eds., Nat. Bur. Stand. (U.S.), Spec. Publ. 394, 183 pages (Apr. 1974) SD Catalog No. C13.10:394.

**Key words:** bubble collapse; cavitation; cavitation damage; cavitation erosion prevention; erosion; surface roughness.

These proceedings consist of a group of 16 submitted papers and discussions from the 19th meeting of the Mechanical Failures Prevention Group which was held at the National Bureau of Standards on October 31 and November 1 and 2, 1973. The central theme of the proceedings is the role of cavitation in mechanical failures. *These proceedings include the following papers (indented):*

**Physics associated with cavitation induced material damage**, F. B. Peterson, *SP394*, pp. 3-12 (Apr. 1974).

**Role of physical properties of liquids in cavitation erosion**, A. Thiruvengadam, *SP394*, pp. 13-22 (Apr. 1974).

**The role of mechanical properties in cavitation erosion resistance**, G. C. Gould, *SP394*, pp. 23-30 (Apr. 1974).

**Recent theories of cavitation damage including nonsymmetrical bubble collapse effects**, F. G. Hammitt, *SP394*, pp. 31-35 (Apr. 1974).

**Some practical examples of cavitation erosion and their prevention**, A. F. Conn, *SP394*, pp. 39-47 (Apr. 1974).



**Examples of oil cavitation erosion in positive displacement pumps,** J. A. Halat and G. O. Ellis, *SP394*, pp. 48-53 (Apr. 1974).

**Microscopic investigation of cavitation erosion damage in metals,** J. V. Hackworth and W. F. Adler, *SP394*, pp. 54-61 (Apr. 1974).

**Lubricant pressure rippling in dynamic Hertzian contacts induced by surface roughness,** T. E. Tallian and J. I. McCool, *SP394*, pp. 62-73 (Apr. 1974).

**Asperity lubrication and cavitation in face seals,** J. A. Walowit, *SP394*, pp. 77-87 (Apr. 1974).

**Effect of cavitation on fluid stability in polymer thickened fluids and lubricants,** J. L. Duda and E. E. Klaus, *SP394*, pp. 88-99 (Apr. 1974).

**Effects of viscoelasticity on cavitation in drag reducing fluids,** R. Y. Ting, *SP394*, pp. 100-106 (Apr. 1974).

**Progress and problems in erosion prediction,** F. J. Heymann, *SP394*, pp. 107-114 (Apr. 1974).

**Potential of thin, sputtered films as erosion resistant protective coatings. Part 1. Sputter-coating and film characteristics,** K. Gentner, *SP394*, pp. 117-128 (Apr. 1974).

**Potential of thin, sputtered films as erosion resistant protective coatings. Part 2. Erosion and the gas turbine engine,** J. E. Newhart, *SP394*, pp. 129-144 (Apr. 1974).

**Rain droplet erosion mechanisms in transparent plastic materials,** G. F. Schmitt, Jr., *SP394*, 145-159 (Apr. 1974).

**Analysis of Navy radome failure problems,** G. J. Tatnall and K. Foulke, *SP394*, pp. 160-165 (Apr. 1974).

**Government-industry data exchange program (GIDEP),** E. T. Richards, *SP394*, pp. 166-170 (Apr. 1974).

**SP395. Simulation and gaming.** Proceedings of the 12th Annual Symposium National Gaming Council and the 4th Annual Conference International Simulation and Gaming Association, held at the National Bureau of Standards, Gaithersburg, Md., September 17-19, 1973, J. E. Moriarty, Ed., Nat. Bur. Stand. (U.S.), Spec. Publ. 395, 458 pages (June 1974) SD Catalog No. C13.10:395.

Key words: computer; decision-making; games; learning; manual games; simulation.

This document contains the proceedings of a Gaming Conference along with many formal papers assembled to provide a comprehensive collection of up-to-date gaming information. The proceedings are divided into three major sections, namely, Theory and Evaluation, Design, and Applications. Each section contains the text of informal workshops held during the Conference and a selection of formal papers. There is a significant amount of reference material cited in the formal papers along with timely questions and challenges explored and amplified in the workshops. *These proceedings include the following papers (indented):*

## THEORY AND EVALUATION TASK GROUP

### Facilitator's Statements:

**Theory and evaluation,** R. A. Schusler, *SP395*, p. 21 (June 1974).

**Evaluation: Classroom uses: Training planning and research uses,** J. C. Thompson, Jr., and C. H. Postma, *SP395*, pp. 22-23 (June 1974).

**Evaluation sub-group facilitator's statement,** S. Thiagarajan, *SP395*, pp. 24-25 (June 1974).

**Evaluation facilitator's statement,** P. Y. Martin, *SP395*, pp. 26-27 (June 1974).

**Sub-group title: Theory and evaluation facilitator's statement,** S. H. Woolard, *SP395*, pp. 28-29 (June 1974).

### Formal Papers:

**Simulating a model of perception to shape problem recognition behavior,** S. H. Woolard, *SP395*, pp. 30-39 (June 1974).

**The what and why of gaming: A taxonomy of experimental learning systems,** B. D. Ruben, *SP395*, pp. 40-55 (June 1974).

**Conflict resolution: From power to peer relations in the helping professions,** P. Y. Martin and M. W. Osmond, *SP395*, pp. 56-73 (June 1974).

**A preliminary investigation of the use of Prince—a man-computer simulation of international relations—in high school courses,** S. J. Kidder, R. E. Horowicz, and G. M. Kiselewich, *SP395*, pp. 74-81 (June 1974).

**Obstacle course,** T. Foster, Jr., *SP395*, pp. 82-90 (June 1974).

**Simulation: An analysis of student cognitive retention and student teacher effective perceptions,** C. H. Postma and J. C. Thompson, Jr., *SP395*, pp. 91-102 (June 1974).

**Simulating an urban school and community for use in teacher education,** F. P. Diulus, *SP395*, pp. 103-112 (June 1974).

**Design, development, and validation of anticipation games,** M. I. Semmel and S. Thiagarajan, *SP395*, pp. 113-127 (June 1974).

**Using simulation to implement TABA's cognitive theory,** R. A. Schusler, *SP395*, pp. 128-134 (June 1974).

**The effect of instructional gaming upon absenteeism: The first step,** L. E. Allen and D. B. Main, *SP395*, pp. 135-158 (June 1974).

**Simulation/gaming: An autotelic inquiry technique,** R. Stadsklev, *SP395*, pp. 159-164 (June 1974).

## DESIGN TASK GROUP

### Facilitator's Statements:

**Developing computer-based simulations, facilitator's statement,** R. I. Miller, *SP395*, pp. 165-166 (June 1974).

**Designing computer-based simulations, facilitator's statement,** M. H. Whithed, *SP395*, pp. 167-168 (June 1974).

**Frame games: Design and redesign,** R. H. Armstrong and M. Hobson, *SP395*, pp. 169-172 (June 1974).

**Frame games: Design and redesign,** E. S. Mulley, *SP395*, pp. 173-174 (June 1974).

**Decision: Futures modeling,** D. L. Little, *SP395*, pp. 175-176 (June 1974).

**Designing interactive social simulations, facilitator's statement,** G. Wilcoxson, *SP395*, p. 177 (June 1974).

**Sub-group: Selecting and developing media in simulation design,** C. H. Adair, *SP395*, pp. 178-179 (June 1974).

**Student designed games, facilitator's statement,** H. Tamminga, *SP395*, p. 180 (June 1974).

**Computer-based gaming models**, P. D. Patterson, *SP395*, p. 181 (June 1974).

**Unstructured and game-generating games, facilitator's statement**, K. F. Dette, *SP395*, pp. 183-184 (June 1974).

#### Formal Papers:

**A process for designing, developing, and evaluating social simulation**, C. H. Adair, *SP395*, pp. 185-196 (June 1974).

**A model for selecting optimum media as part of the simulation design process**, C. H. Adair, *SP395*, pp. 197-203 (June 1974).

**Where all else fails—an approach to defining the possible uses of gaming-simulation in the decision-making process**, R. H. R. Armstrong and M. Hobson, *SP395*, pp. 203-217 (June 1974).

**Simulated universities**, H. A. Becker, *SP395*, pp. 218-238 (June 1974).

**The data behind simulation models**, H. A. Becker, *SP395*, pp. 239-249 (June 1974).

**Simulating alternative futures for American education**, J. Debenham, *SP395*, pp. 250-274 (June 1974).

**A guide for simulation design**, C. H. Adair and J. T. Foster, Jr., *SP395*, p. 275 (June 1974).

#### APPLICATIONS TASK GROUP

##### Facilitator's Statements:

**Applications: Research, facilitator's statement**, R. L. Dukes, *SP395*, p. 303 (June 1974).

**Medicine and social welfare, facilitator's statement**, J. T. Foster, Jr., *SP395*, pp. 304-305 (June 1974).

**Teaching-training: Urban planning**, D. E. LaHart, *SP395*, p. 306 (June 1974).

**Teaching-training: Elementary-secondary education**, H. E. Arnold, *SP395*, p. 307 (June 1974).

**Community and public policy applications of gaming simulation**, J. R. Hanson, *SP395*, p. 308 (June 1974).

**Community and public policy applications**, G. M. McFarland, *SP395*, p. 308 (June 1974).

**Issues in game use: What values are conveyed by game designers and users**, G. M. McFarland, *SP395*, pp. 309-311 (June 1974).

##### Formal papers:

**Simulations and games as growth group experiences**, J. F. Karshmer, *SP395*, pp. 312-315 (June 1974).

**The disorganized health clinic as a simulation**, J. T. Foster, Jr., *SP395*, pp. 316-323 (June 1974).

**Simulation and gaming as aids in regional and intercommunity problem solving**, H. Sievering and J. Sinopoli, *SP395*, pp. 324-334 (June 1974).

**Paying the piper or pay us again**, Sam, S. Cipinko, *SP395*, pp. 335-340 (June 1974).

**Public policy applications**, G. McFarland, *SP395*, pp. 341-342 (June 1974).

**Massive management gaming**, R. F. Barton, *SP395*, pp. 343-351 (June 1974).

**Simulating sexism: Unintentional (?) replication of reality**, N. D. Glandon, *SP395*, pp. 352-357 (June 1974).

**Advocacy—a community planning game for the ranking of school system goals and training needs**, J. R. Hanson, *SP395*, pp. 358-364 (June 1974).

**Learning tools to research instruments: A research package for starpower**, R. L. Dukes, *SP395*, pp. 365-373 (June 1974).

**A pedagogical schema for the development and use of computer simulation technology**, D. B. Main, R. Stout, D. W. Rajecki, H. Eichenbaum, and T. Villars, *SP395*, pp. 374-381 (June 1974).

**Education and training for contemporary urban planning systems: The impact of interactive simulation**, R. M. Sarly, *SP395*, pp. 382-396 (June 1974).

**The publication and distribution of simulation games**, I. B. Naiburg, Jr., *SP395*, p. 397 (June 1974).

#### TASK GROUP SUMMARIES

**Design sub-group summary: Computer-based gaming simulations**, P. D. Patterson, *SP395*, pp. 398-399 (June 1974).

**Urban planning sub-group: Summary paper**, D. E. LaHart, *SP395*, pp. 405-406 (June 1974).

**Teaching and training sub-group: Business summary state of the art**, M. Uretsky and R. F. Barton, *SP395*, pp. 407-408 (June 1974).

**Research applications of simulation games: Summary paper**, R. L. Dukes, *SP395*, pp. 409-412 (June 1974).

**SP396-1. Critical surveys of data sources: Mechanical properties of metals**, R. B. Gavert, R. L. Moore, and J. H. Westbrook, Nat. Bur. Stand. (U.S.), Spec. Publ. 396-1, 90 pages (Sept. 1974) SD Catalog No. C13.10:396-1.

**Key words:** commercial alloys; data sources; mechanical properties; metals.

This study was undertaken with the objective of providing a detailed critical survey of the existent sources of mechanical property data for commercially available metals and alloys. This survey was intended to assess the scope, assets and deficiencies of about forty of the most prominent sources of such information. There were included: handbooks and technical compilations, information centers, foreign information sources, technical societies, and trade associations. The initial listing of sources to be examined was prepared by the authors with the advice and the assistance of a subcommittee of the Metals Properties Council. The aim was to restrict the survey to sources which actually had compilations of mechanical property data in some form. Thus sources which offered only generalized guides to the literature, monographs, textbooks, or periodicals publishing original research or engineering articles were not to be included. Those sources from the original listing which were found upon detailed examination to fall into the latter categories are therefore treated in a separate appendix.

**SP398. Fundamental physical constants**, B. N. Taylor, Nat. Bur. Stand. (U.S.), Spec. Publ. 398, card (Aug. 1974) SD Catalog No. C13.10:398.

**Key words:** fundamental constants.

This card gives values of the fundamental constants resulting from the "1973 Least-Squares Adjustment of the Fundamental Physical Constants" carried out by E. R. Cohen and B. N. Taylor under the auspices of the CODATA Task Group on Fundamental Constants and adopted for international use by CODATA. These constants have been previously given in J. Phys. Chem. Ref. Data 2, 663 (1973) and CODATA Bulletin No. 11 (Dec. 1973). Supersedes NBS SP344.



SP399. Volume 1. **NBS FORTRAN test programs. Volume 1—documentation for versions 1 and 3**, F. E. Holberton and E. G. Parker, Nat. Bur. Stand. (U.S.), Spec. Publ. 399, 171 pages (Oct. 1974) SD Catalog No. C13.10:399/V.1.

Key words: computer programming language; FORTRAN; FORTRAN validation; language validation; standard FORTRAN; test program design.

The NBS FORTRAN test programs, written in Standard FORTRAN, are designed to test whether a FORTRAN compiler accepts the forms and interpretations of the FORTRAN language as described in the American National Standard FORTRAN document X3.9-1966. The test programs, comprised of 116 test units, are structured into two versions, each containing approximately 14,500 punch card images. The test units may be used as separate executable FORTRAN programs, or may be linked end to end with other test units, with a minimum of user effort, to improve operating efficiency. Version 1 is structured into 116 executable FORTRAN programs, and Version 3, containing the same 116 test units, is structured into 14 executable FORTRAN programs for use on large FORTRAN processors.

The test program design criteria was to: Constrain all test programs to the FORTRAN Standard X3.9-1966; Reduce the effect of those areas in which the FORTRAN Standard does not prescribe a method or solution, e.g., range, precision, size of computer, etc.; Simplify the use of the FORTRAN test programs; Test FORTRAN language elements before they are used in support of other tests; Maintain an open ended system so that tests may be changed or added.

The test programs require the use of a card reader, printer and one intermediate tape unit.

SP399. Volume 2. **NBS FORTRAN test programs. Volume 2—listings for version 1**, F. E. Holberton and E. G. Parker, Nat. Bur. Stand. (U.S.), Spec. Publ. 399, 221 pages (Oct. 1974) SD Catalog No. C13.10:399/V.2.

Key words: computer programming language; FORTRAN; FORTRAN validation; language validation; standard FORTRAN; test program design.

THE NBS FORTRAN test programs, written in Standard FORTRAN, are designed to test whether a FORTRAN compiler accepts the forms and interpretations of the FORTRAN language as described in the American National Standard FORTRAN document X3.9-1966. The test programs, comprised of 116 test units, are structured into two versions, each containing approximately 14,500 punch card images. The test units may be used as separate executable FORTRAN programs, or may be linked end to end with other test units, with a minimum of user effort, to improve operating efficiency. Version 1 is structured into 116 executable FORTRAN programs, and Version 3, containing the same 116 test units, is structured into 14 executable FORTRAN programs for use on large FORTRAN processors.

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The test programs require the use of a card reader, printer and one intermediate tape unit.

SP399. Volume 3. **NBS FORTRAN test programs. Volume 3—listings for version 3**, F. E. Holberton and E. G. Parker, Nat. Bur. Stand. (U.S.), Spec. Publ. 399, 226 pages (Oct. 1974) SD Catalog No. C13.10:399/V.3.

Key words: computer programming language; FORTRAN; FORTRAN validation; language validation; standard FORTRAN; test program design.

The NBS FORTRAN test programs, written in Standard FORTRAN are designed to test whether a FORTRAN compiler accepts the forms and interpretations of the FORTRAN language as described in the American National Standard FORTRAN document X3.9-1966. The test programs, comprised of 116 test units, are structured into two versions, each containing approximately 14,500 punch card images. The test units may be used as separate executable FORTRAN programs, or may be linked end to end with other test units, with a minimum of user effort, to improve operating efficiency. Version 1 is structured into 116 executable FORTRAN programs, and Version 3, containing the same 116 test units, is structured into 14 executable FORTRAN programs for use on large FORTRAN processors.

The test program design criteria was to: Constrain all test programs to the FORTRAN Standard X3.9-1966; Reduce the effect of those areas in which the FORTRAN Standard does not prescribe a method or solution, e.g., range, precision, size of computer, etc.; Simplify the use of the FORTRAN test programs; Test FORTRAN language elements before they are used in support of other tests; Maintain an open ended system so that tests may be changed or added.

The test programs require the use of a card reader, printer and one intermediate tape unit.

SP400-1. **Semiconductor measurement technology. Quarterly report, July 1 to September 30, 1973**, W. M. Bullis, Ed., Nat. Bur. Stand. (U.S.), Spec. Publ. 400-1, 68 pages (Mar. 1974) SD Catalog No. C13.10:400-1.

Key words: contact resistance; die attachment; dopant profiles; electrical properties; electronics; gold-doped silicon; hermeticity; metallization; methods of measurement; microelectronics; microwave diodes; mobility; MOS devices; oxide films; photomasks; photoresist; resistivity; resistivity standards; scanning electron microscopy; semiconductor devices; semiconductor materials; semiconductor process control; sheet resistance; silicon; S-parameters; spreading resistance; test patterns; thermal resistance; thermally stimulated capacitance; thermally stimulated current; wire bonds.

This quarterly progress report, twenty-first of a series, describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Principal accomplishments during this reporting period include (1) extension of the technique for measuring thermally stimulated current and capacitance to include measurements on MOS capacitors, (2) completion of the development of the thermal response method for evaluation of transistor die attachment, (3) analysis of the interlaboratory comparison of transistor scattering parameter measurements, (4) preliminary review of measurement problems in the photolithographic aspects of semiconductor device processing, of problems associated with certain hermeticity testing procedures, and of methods for evaluating metallization step coverage, and (5) initiation of new activity on characterization of oxide films in MOS structures and analysis of diffusion profiles. Results are also reported on spreading resistance, capacitance-voltage, and sheet resistance measurements; the activation energy of the gold acceptor in silicon; evaluation of the base-to-metal contact resistor test structure; metallurgical systems for ultrasonic bonding; burn-out characteristics of fine gold and aluminum bonding wire; transistor thermal resistance measurements; and microwave diode conversion loss measurements. Supplementary data concerning staff, publications, workshops and symposia, standards committee activities, and technical services are also included as appendices.



**SP400-2. Semiconductor measurement technology: Microelectronic ultrasonic bonding**, G. G. Harman, Ed., Nat. Bur. Stand. (U.S.), Spec. Publ. 400-2, 109 pages (Jan. 1974) SD Catalog No. C13.10:400-2.

**Key words:** bonding; degradation (wire bond); discrete devices; electrical interconnection; fabrication (wire bond); failure (wire bond); hybrid circuits; integrated circuits; microelectronics; reliability; semiconductor devices; testing (wire bond); ultrasonic bonding; wire bond.

This report primarily comprises excerpts of the work done under the NBS ultrasonic wire bonding program that was previously published in 17 quarterly and other reports. The material is organized into subject groupings with the intention of presenting in convenient form sufficient information for making high quality ultrasonic wire bonds as well as imparting a basic understanding of the ultrasonic systems used. The work emphasizes problems and methods of solving them. To accomplish this, the required measurement equipment is first introduced. This is followed by procedures and techniques used in setting up a bonding machine, and then various machine- or operator-induced reliability problems are discussed. The characterization of the ultrasonic system and its problems are followed by in-process bonding studies and work on the ultrasonic bonding (welding) mechanism. The report concludes with a discussion of various effects of bond geometry and wire metallurgical characteristics. Where appropriate, the latest, most accurate value of a particular measurement has been substituted for an earlier reported one. Thus all of the included material is up to date.

**SP400-3. Semiconductor measurement technology: ARPA/NBS workshop I. Measurement problems in integrated circuit processing and assembly**, H. A. Schafft, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-3, 24 pages (Feb. 1974) SD Catalog No. C13.10:400-3.

**Key words:** die bonding; hermeticity; integrated circuits; measurement methods; microelectronics; oxides; photolithography; process control; reliability; semiconductor devices; silicon; wire bonding.

The dual purpose of the workshop was (1) to announce and describe the new effort, "Advancement of Reliability, Processing, and Automation for Integrated Circuits with the National Bureau of Standards," sponsored by the Defense Advanced Research Projects Agency (ARPA), and (2) to obtain additional input on critical measurement problems in integrated circuit processing and assembly to assist in planning future work in the effort. More than 130 engineers representing 61 organizations from the electronics industry and government participated in the workshop. The measurement problems in silicon, oxides, photolithography, and assembly and the problems in information dissemination that were identified by the participants are summarized. Included as appendices are summaries of two talks given: one which described the results of earlier direct contacts with a cross section of industrial representatives on major measurement problems in integrated circuit processing and assembly and the other which described the initial plans for work in the new effort.

**SP400-4. Semiconductor measurement technology. Combined quarterly report, October 1, 1973 to March 31, 1974**, W. Bullis, Ed., Nat. Bur. Stand. (U.S.), Spec. Publ. 400-4, 101 pages (Nov. 1974) SD Catalog No. C13.10:400-4.

**Key words:** boron redistribution; collector resistor; doping profiles; effective masses; electrical properties; electron beam induced current mode electronics; epitaxial layer thickness; flying spot scanner; gold-doped silicon; hermeticity; ion microprobe mass analysis; methods of measurement; microelectronics; microwave diodes; mobility;

MOS devices; oxide films; photomasks; photoresist; platinum wire resistivity; resistivity standards; ribbon wire scanning electron microscopy; semiconductor devices; semiconductor materials; semiconductor process control; sheet resistance; silicon; spreading resistance; test patterns; thermal response; thermally stimulated capacitance; thermally stimulated current; thick film copper; voltage contrast mode; wire bonds; x-ray photoelectron spectroscopy.

This combined quarterly progress report describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Principal accomplishments during this reporting period include (1) identification of major problem areas in connection with measuring and inspecting photomasks, (2) development of a mathematical model suitable for interpreting thermally stimulated current and capacitance measurements on junction diodes and metal-oxide-semiconductor (MOS) capacitors, (3) completion of a preliminary evaluation of a method, based on the transient capacitance-voltage characteristic of an MOS capacitor, for measuring thickness of epitaxial layers up to 2  $\mu\text{m}$ , and (4) development of criteria for use in nondestructive wire bond pull tests. Results are also reported on spreading resistance, capacitance-voltage, and carrier mobility measurements; polynomial fits for energy band gap and hole and electron effective masses in silicon; methods for characterizing oxide films; evaluation of sheet resistance and collector resistor test structures; evaluation of a photoresist spinner test; scanning electron microscopy; bonding of aluminum ribbon wire to thick film copper; bonding of platinum wire to thin film aluminum; leak rate calculations in the transition flow regime; transistor thermal response measurements; and radiation response of microwave mixer diodes. Supplementary data concerning staff, publications, workshops and symposia, standards committee activities, and technical services are also included as appendices.

**SP400-6. Semiconductor measurement technology: Microelectronic test patterns: An overview**, M. G. Buehler, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-6, 24 pages (Aug. 1974) SD Catalog No. C13.10:400-6.

**Key words:** integrated circuits; microelectronic test patterns.

The test patterns considered are those designed by the physical electronics engineer to evaluate fabrication processes rather than those designed by the microcircuit designer. The evaluation of fabrication processes can reveal if a process is under control and can indicate the stability and reliability of the resulting microcircuit. This evaluation is in essence an evaluation of a microcircuit's material characteristics, for process control and reliability depend ultimately on the right atoms being in the right places.

Various material analysis test structures are described, such as resistors, MOS capacitors, and gated  $p$ - $n$  junctions along with the material parameters that can be derived from each. These test structures are illustrated by the NBS-2 test pattern, and its use in process control is described. Examples are given which span the range from those structures which are amenable to production testing to those which require an advanced measurement capability. In addition test structures are discussed with regard to their usability; this encompasses their size, sensitivity, correlation, contacting schemes, testability, and packaging. Test structures must be properly designed so that desired parameters are measured. In this regard various design aspects such as metal taps and diffused taps are mentioned. Finally the role of NBS in evaluating and designing test patterns is discussed.

**SP400-9. Semiconductor measurement technology: ARPA/NBS Workshop II. Hermeticity testing for integrated circuits**, H. A. Schafft, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-9, 43 pages (Dec. 1974) SD Catalog No. C13.10:400-9.



Key words: bubble test; gas analysis; helium leak test; hermeticity; integrated circuits; measurement methods; microelectronics; radioisotope test; seals; semiconductor devices; weight test.

Synopses are presented of the six invited talks and two discussion periods of a meeting in which 65 engineers and scientists, representing 36 organizations from private industry and government, participated. Topics ranged from failure analysis and the nature of leaks to evaluations and intercomparisons of bubble, weight, helium, and radioisotope tests. Underlying many of the problems discussed is the lack of a technical basis for specifications on maximum allowable leak rates and contaminant levels; no data is available to relate leak rate to component life. Of concern is the proliferation of test conditions which has complicated testing and test intercomparison efforts, and has resulted, unwittingly, in testing devices to significantly different actual leak rate criteria. Water vapor, sealed-in and that which penetrates the package, is a contaminant of major concern, and the difficulties of making sufficiently accurate measurements of water vapor were detailed. The control required in the materials and assembly process to avoid hermeticity failure and false leak indications in ceramic, dual in-line packages were discussed. Finally, the importance of performing some hermeticity tests at elevated temperatures was cited.

**SP400-10. Semiconductor Measurement Technology: Spreading Resistance Symposium.** Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, Md., June 13-14, 1974, J. R. Ehrstein, Ed., Nat. Bur. Stand. (U.S.), Spec. Publ. 400-10, 293 pages (Dec. 1974) SD Catalog No. C13.10:400-10.

Key words: dopant concentration; dopant profiles; metal-semiconductor contacts; resistivity; semiconductor surface preparation; silicon; spreading resistance.

This Proceedings contains the information presented at the Spreading Resistance Symposium held at the National Bureau of Standards on June 13-14, 1974.

This Symposium covered the state of the art of the theory, practice and applications of the electrical spreading resistance measurement technique as applied to characterization of dopant density in semiconductor starting materials and semiconductor device structures. In addition to the presented papers, the transcripts of the discussion sessions which were held directly after the Theory, Practice and Applications sessions are also included. These transcripts, which were reviewed by the respective respondents for clarity, are essentially as presented at the Symposium. *These proceedings include the following papers (indented):*

**The physics of spreading resistance measurements,** S. J. Fonash, *SP400-10*, pp. 17-26 (June 1974).

Key words: correction factor; crystallographic orientations; effective contact radius; interfaces; metal-semiconductor contacts; multilayered structure; piezoresistivity; resistivity; spreading resistance; stress; zero bias resistance.

The spreading resistance method is uniquely suitable for the determination of electrical resistivities in a number of situations. However the technique does not simply measure the resistivity beneath the contacts. Considering the two probe configuration, what is actually measured is the ratio  $\Delta V/I$ . Here  $\Delta V$  is the difference between the Fermi levels of the probes necessary to maintain the sampling current  $I$ . This difference in the Fermi levels of the probes depends on the zero bias resistance of the probe—semiconductor contacts, the effective resistivity of the layers in a multilayer structure, and the configuration of the structure. The zero bias resistance depends on temperature and details of the metal-semiconductor contact including surface history. Ef-

fective resistivities enter into the measurement—and not the actual resistivities—because of the fact that the use of pressure probes creates a stress field under the contacts. This field falls off with a characteristic length of the order of the contact radius. Thus piezoresistivity effects—well known for Si—can be operative under the contacts. As a consequence of these various effects the interpretation of what  $\Delta V/I$  is actually measuring is not straightforward. Practical application of the spreading resistance technique necessitates making certain simplifying assumptions. In light of the various phenomena involved in a spreading resistance measurement it is imperative that the implications of these assumptions to the accuracy of the measurement be understood.

**Formal comparison of correction formulae for spreading resistance measurements on layered structures,** P. J. Severin, *SP400-10*, pp. 27-44 (June 1974).

Key words: contact resistance; correction formulae; sheet resistance; silicon; spreading resistance.

The spreading resistance of a metal contact on a semiconductor sample is analysed for infinite geometry, with three different boundary conditions: a specified potential of the contact, a uniform contact current density and a current density dependent on contact resistance. The cases of a thin layer on a perfectly conducting substrate and on a non-conducting substrate are analysed each for the boundary conditions of uniform current density and of the current density distribution valid for the infinite geometry. With a perfectly conducting substrate the two boundary conditions yield about 10 percent difference. With a non-conducting substrate calculations based on both current density distributions produce in the thin layer approximation the same  $\ln r$  dependence required. The constant terms in both approaches are different by 5 percent and the constant current density result in addition agrees with the result obtained with a totally different transmission-line approach. The actual three-point-probe measurement situation is discussed. The danger of correcting the precise spreading resistance measurement results with an error of 1 percent, with formulae derived on the basis of a formal model which is sensitive to the choice of the boundary conditions by up to 10 percent, is stressed. The effects of undefined thickness, bevel edge and transition layer curving upwards are mentioned as further complications.

**Two-point probe correction factors,** D. H. Dickey, *SP400-10*, pp. 45-50 (June 1974).

Key words: boundary correction; calculations; electrostatic analogue; resistivity; semiconductor; spreading resistance.

The effects of sample boundaries on resistivity measurements made with a two-point spreading resistance probe are calculated for various boundary conditions. The results are presented in the form of dimensionless correction factors. The problem of depth-dependent resistivity in a thin layer is considered, and a method for correcting measurements on such layers is described.

**On the validity of correction factors applied to spreading resistance measurements on bevelled structures,** P. M. Pinchon, *SP400-10*, pp. 51-61 (June 1974).

Key words: accuracy; bevelled structures; correction application; correction factors; edge effect; profiles; resistivity profiling; small spacing; spreading resistance.

The correction factors in spreading resistance measurements are generally determined by using a plan-parallel model of a single or multi-layer structure. This paper will discuss the applicability of these factors to the profiling mea-



surements on a bevel, and call attention to possible systematic errors which can appear in the case of an insulated layer or a low/high type of structure.

After a short discussion on the spacial resolution of the spreading resistance probe, the case of a homogeneous isolated layer is examined in more detail. A simplified expression for the value of spreading resistance was calibrated against published data using fitting coefficients.

It is then easy to show that the use of a correction derived for parallel structures is not correct for the case of a thin, isolated layer, when the measurement is made on a bevel.

Indications are also given on the parameters which could minimise the problem.

The experimental part of this paper shows a series of profiles made with P-type epitaxial layers.

After the application of the usual corrections, the various electrical boundaries or geometrical conditions are seen to affect the results in accordance with the discussion. An edge effect which is significant even at great distance from the edge, is also described.

In the absence of a three dimensional theory for correction, the use of small spacing is recommended in conjunction with a small radius of contact and a shallow bevelling angle.

**SRPROF, a fast and simple program for analyzing spreading resistance profile data**, B. L. Morris and P. H. Langer, *SP400-10*, pp. 63-74 (June 1974).

Key words: resistivity profiles; spreading resistance; thin film correction factors.

The spreading resistance technique is an excellent method of measuring epitaxial resistivity profiles. In many cases it is the only method by which the complete profile may be measured. However, thin film correction factors must be used to convert the spreading resistance into a corrected resistivity. Previous calculations of these correction factors have emphasized a mathematically complex solution which necessitates the use of a large computer. The correction factors used here are calculated from a relatively simple algorithm which allows the use of a minicomputer. A documented program is presented which uses these algorithms. This program, written in FOCAL for use on the PDP8 series of minicomputers, is fast, accurate, easy to use, and provides a complete data reduction system. Examples of corrected spreading resistance profiles are presented, and compared with independent results such as diode C-V and four point probe measurements.

**Multilayer analysis of spreading resistance measurements**, G. A. Lee, *SP400-10*, pp. 75-94 (June 1974).

Key words: computer modeling; correction factors; dopant profiles; multilayer spreading resistance model; resistivity; semiconductor dopant concentration; spreading resistance.

Spreading resistance measurements provide a highly flexible technique for the determination of dopant profiles in semiconductors. However, because each measurement samples a greater depth into the sample than the depth difference between successive measurements, the direct conversion of resistivity readings to dopant concentration values will not yield a correct profile.

The technique discussed in this report analyzes direct spreading resistance readings to deduce a "true" dopant profile. The model used is that of circular contacts to a laterally infinite medium which is partitioned vertically into layers of homogeneous resistivity, each layer corresponding to one spreading resistance measurement point. The analysis is performed by a computer program. Some detail in the development of the program is discussed.

The results of this analysis technique compare favorably to profile results of other profiling techniques such as capacitance voltage and incremental sheet resistance on profile types to which they can be applied. The program execution time is usually fast enough that the computer charge is less than the direct charge billed for making the spreading resistance measurements.

**An automated spreading resistance test facility**, J. C. White, Jr., *SP400-10*, pp. 95-98 (June 1974).

Key words: automated testing; epitaxial silicon; impurity concentration; resistivity; semiconductor materials; silicon; spreading resistance.

An automated spreading resistance test facility has been designed and constructed at the Allentown Works of the Western Electric Co. This system has been shown to provide a rapid, semi-nondestructive, and reproducible measurement of epitaxial layer resistivity which can be used in a production environment. The system has the advantages of operator independence, well protected probes, and four-inch capability. Surface or in-depth measurements can be performed with on-line calculations of resistivity and impurity concentration. Cycle time is less than five seconds per measurement and system reproducibility is  $\pm 1.3$  percent (IS).

**Angle-bevelling silicon epitaxial layers, technique and evaluation**, P. J. Severin, *SP400-10*, pp. 99-108 (June 1974).

Key words: bevel; interferometer; jig; microcontacts; silicon; spreading resistance; steel probe; topography.

The properties of a steel probe for a spreading-resistance system are discussed stressing the effect of micro- and macrocontacts. The need is explained for producing small-angle bevels and a lapping jig for making such bevels is described. With small-angle bevels the slice topography cannot be neglected and a simple instrument is described by which the surface topography of the whole slice can be recorded. By recording the slice topography before and after bevelling the local reduction of thickness by the bevelling process is determined. This method can be used for angles between 1/500 and 1/2000. It is indispensable for the proper interpretation of spreading resistance measurements on bevelled N on N<sup>+</sup> junctions.

**Spreading resistance measurements on silicon with non-blocking aluminum-silicon contacts**, J. Krausse, *SP400-10*, pp. 109-122 (June 1974).

Key words: absolute measurements; aluminum-silicon contact; four-point probe measurements; local resolution; *n*-type silicon; resistivity inhomogeneities; spreading resistance; striations.

The paper concerns the measurement of resistivity fluctuations in *n*-type silicon starting material in the resistivity range from 1 to 1000  $\Omega$  cm. The microscopic resistivity fluctuations that are associated with the well-known striations require a measurement technique of high accuracy and high local resolution. We chose the spreading resistance method. However, in contrast to the conventional method, in which the metal probe is pressed directly onto the silicon surface, we supply the silicon slice with non-blocking aluminum-silicon contacts. The radius of the contact area is exactly defined. Any contact radius can be realized according to the resolution desired in lateral direction and in depth. When the metal probe is applied to the aluminum-silicon contact, the contact is not destroyed. Thus it is possible to perform spreading resistance measurements and four-point probe measurements along one and the same measuring track and in this manner at the same time to vary the local resolution.



A comparison of both measurement results will in particular yield information on the conditions of the resistivity in axial direction of the slice. Essential prerequisites for an absolute measurement are fulfilled with the aluminum-silicon contact. However, the investigations made up to now show that the resistivity calculated from the spreading resistance is smaller than the one obtained with the four-point probe measurement by approximately a factor of 0.8.

**The preparation of bevelled surfaces for spreading resistance probing by diamond grinding and laser measurement of bevel angles,** A. Mayer and S. Schwartzman, *SP400-10*, pp. 123-136 (June 1974).

Key words: bevelling; diamond grinding; laser bevel angle measurement; layer thickness determination; materials; resistivity measurement; silicon doping profiles; spreading resistance measurement; surface damage.

A rapid and reproducible method for preparing bevelled surfaces on silicon has been developed as a preliminary to spreading resistance probe measurement of doping profiles or junction depth determination by staining. Several chips can be bevelled simultaneously. The sample is mounted on a carrier which is clamped on the tilting table of a microtome. The tilt is adjusted until a laser beam reflected from the surface to a calibrated wall chart is deflected to the desired angle. The bevel is then ground with a high-speed diamond wheel mounted on the microtome, taking cuts of several micrometers at a time. The bevel edge is clearly defined even for very shallow angles. The angle is accurately measured with the same laser.

Because the ground surface is highly reflective, in contrast to a lapped surface, a good reading of very small angles of less than 30 minutes can be obtained. Up to a 6 meter base line is used with a 1mw He-Ne laser and the reflection is visible in normal room light.

Factors entering into spreading resistance are discussed, such as mechanical damage incurred in bevelling, probe impact damage, and surface cleanliness. Judged by spreading resistance, the amount of damage incurred during grinding is small and reproducible, provided care is taken to maintain the spindle so that it runs without vibrating.

**Spreading resistance correction factors for (111) and (100) surfaces,** H. Murrmann and F. Sedlak, *SP400-10*, pp. 137-144 (June 1974).

Key words: contact radius; correction factors; silicon; spreading resistance; surface orientation.

The effective contact radius for spreading resistance measurements on Si has been evaluated by comparison of S.R. for epitaxial layers limited by a *pn*-junction or by a well conducting buried layer for different crystal orientation. The contact radius on (100) surfaces showed to be greater by a factor of 1.26 than for a (111) plane. Furthermore measurements were made on samples for both (100) and (111) orientation in the resistivity range of 0.01 to 80Ω cm with *n* and *p*-type doping. Data for spreading resistance and resulting from the predetermined contact radius for the resistivity dependent correction factor are given.

**On the calibration and performance of a spreading resistance probe,** H. J. Ruiz and F. W. Voltmer, *SP400-10*, pp. 145-154 (June 1974).

Key words: automated resistivity measurements; calibration; germanium characterization; sample preparation; silicon characterization; spreading resistance; surface effects.

In this paper, techniques are presented for material standards selection for calibration purposes, materials and calibration block preparation, and techniques for data col-

lection and processing for the spreading resistance probe. A description of the variation with time of the calibration of a spreading resistance probe is presented. Problems encountered with characterization of high resistivity *p*-type silicon are discussed, and examples of the probe performance in the characterization of germanium are also presented.

**Comparison of the spreading resistance probe with other silicon characterization techniques,** W. H. Schroen, G. A. Lee, and F. W. Voltmer, *SP400-10*, pp. 155-168 (June 1974).

Key words: automation; bevelling; comparison; four-point probe; incremental MOS capacitance-voltage; incremental sheet resistance; infrared spectrometer; ion microprobe; junction capacitance-voltage; lap and stain; mercury probe; scanning Michelson interferometer; Schottky capacitance-voltage; spreading resistance.

Range and precision of doping concentration data in silicon materials gained by the spreading resistance technique are compared to values obtained by other characterization methods. They include junction and MOS capacitance-voltage techniques, mercury probe, four-point probe, incremental sheet resistance technique, ion microprobe, and optical methods. The comparison considers precision and resolution of each technique, range of silicon resistivities and layer thicknesses, experimental effort, analytical interpretation, and time and cost of data acquisition and evaluation. Examples are presented which demonstrate the range of applicability of each technique and how they can supplement each other so that they cover the total doping range of silicon devices.

**Preparation of a lightly loaded, close-spaced spreading resistance probe and its application to the measurement of doping profiles in silicon,** J. L. Deines, E. F. Gorey, A. E. Michel, and M. R. Poponiak, *SP400-10*, pp. 169-178 (June 1974).

Key words: bevel angle measurement; correction factor; epitaxial layer; impurity concentration; ion-implanted layer; neutron activation; probe loading; probe spacing; spreading resistance.

A commercially available spreading resistance probe, the ASR-100, was modified to operate with lighter probe loading and smaller probe spacing. The advantages of device structure profiling, increased resolution, and reduction in the "correction factor" in the converted impurity concentration profile are realizable with smaller probe spacing. The effect of the probe modifications on sample profiles and profile quality is discussed for thin epitaxial layers, bipolar transistor structures, and ion-implanted layers. Sample preparation, as influenced by the beveling technique, is also shown to have an effect on profile quality. A novel method for precise measurement of very small bevel angles is described.

**A direct comparison of spreading resistance and MOS-CV measurements of radial resistivity inhomogeneities on PICTUREPHONE® wafers,** J. R. Edwards and H. E. Nigh, *SP400-10*, pp. 179-184 (June 1974).

Key words: dark field coring; MOS-CV techniques; PICTUREPHONE®; radial resistivity inhomogeneities; silicon resistivity; spreading resistance techniques.

Small scale (~ 50 μm) radial impurity concentration inhomogeneities in silicon wafers have been measured using both the MOS-CV method and the spreading resistance technique. The MOS-CV measurements were made using photolithographically defined 50 μm square capacitors placed on 75 μm centers and the spreading resistance measurements were made using a model 100 ASR probe on the same wafers after removal of the MOS capacitors.



A direct comparison between these methods is presented for three specific types of (111) oriented silicon wafers with an impurity concentration range between  $5$  and  $10 \times 10^{14}/\text{cm}^3$ . In addition, a photograph showing the direct effect of radial resistivity variations on the dark field coring of a PICTUREPHONE® target is included.

**Investigations on local oxygen distribution in silicon single crystals by means of spreading resistance technique**, F. G. Vieweg-Gutberlet, *SP400-10*, pp. 185-190 (June 1974).

Key words: oxygen in silicon; silicon single crystals; spreading resistance measurements; swirls.

By means of spreading resistance measurements subsequent to heat-treatments at approx.  $450^\circ\text{C}$  and  $1100^\circ\text{C}$  alternatively the local distribution of oxygen in the donor state in silicon single crystals was examined. Oxygen striations have not been found which are in correspondence to a distribution coefficient of  $k_0 = 1.25 \pm 0.17$  for oxygen in silicon. The radial distribution of oxygen in the donor state is more or less uniform except for an edge area of about  $1.5$  mm where the oxygen content seems to be considerably lower. A very strong relationship between electrically activated oxygen (donor state) and swirls was found: in regions containing swirls a smaller amount of oxygen was activated to the donor state. This result fits De Kock's model describing swirls as consisting of vacancy-OXYGEN-clusters.

**Use of the spreading resistance probe for the characterization of microsegregation in silicon crystals**, F. W. Voltmer and H. J. Ruiz, *SP400-10*, pp. 191-199 (June 1974).

Key words: crystal growth; Czochralski; Fourier transform; microsegregation; resistivity characterization; silicon; spreading resistance.

A technique for using the spreading resistance probe to quantitatively characterize microsegregation in single crystal silicon is presented. For the first time, the use of Fourier transformations of the resistivity is developed to provide accurate quantitative information as to the periodicity and amplitude of the various components giving rise to the resistivity variations. It is demonstrated that the probe is reproducible and is capable of measuring fluctuations in resistivity to  $\pm 1$  percent, which is well below the normally observed microsegregation. Examples of the use of the technique are given by characterizing microsegregation in two Czochralski grown crystals and one modified float zone crystal. The periodicity of the principle resistivity fluctuation of the Czochralski grown crystals is evaluated by Fourier transform analysis and agrees well with the anticipated fluctuations in impurity incorporation based on growth parameters.

**Effects of oxygen and gold on silicon power devices**, J. Assour, *SP400-10*, pp. 201-208 (June 1974).

Key words: gold in silicon; oxygen in silicon.

Several important features that make the two-probes spreading resistance technique a unique process control tool for designing and manufacturing silicon power devices are elucidated in terms of the effects of electrically active oxygen and gold centers on the characteristics of transistors, thyristors, and rectifiers. The effectiveness of the spreading resistance technique is compared to other commonly practiced techniques for the investigation of diffusion mechanisms of oxygen in homotaxial NPN transistors and of gold in fast switching rectifiers and thyristors.

**The evaluation of thin silicon layers by spreading resistance measurements**, G. A. Gruber, *SP400-10*, pp. 209-216 (June 1974).

Key words: diffusion; epitaxy; ion implantation; microwave devices; profiling; spreading resistance; thin silicon layers.

The spreading resistance measurement technique is the only one capable of providing precise thickness measurements and detailed concentration profiles on any type of active device layer or structure formed in silicon on a routine basis. The methods employed in the evaluation of thin layer structures of the type used for microwave devices is discussed and the application of these methods to thin  $\text{NN}^+$ ,  $\text{P}^+\text{NN}^+$  and  $\text{P}^+\text{N}$  silicon structures formed by combinations of diffusion, epitaxy and ion implantation is illustrated.

**Evaluation of the effective epilayer thickness by spreading resistance measurement**, H. Murrmann and F. Sedlak, *SP400-10*, pp. 217-221 (June 1974).

Key words: epilayer thickness; silicon; spreading resistance; test pattern.

Two types of double layer structure which are dealt with in the multilayer theory have been examined: 1) a top layer is insulated against a bottom layer (i.e.  $\text{pn}$ -junction,  $R(\infty)$ ); 2) a top layer is shorted by a bottom layer (i.e.  $\text{n}^+$ -buried layer,  $R(0)$ ). In both arrangements the Spreading Resistance depends strongly on layer thickness  $d$  and on the radius  $a$  of contact area. Knowing the effective radius the epilayer thickness can easily be evaluated from Spreading Resistance Measurement and making use of the function  $R(\infty)/R(0) = f(d/a)$ . This method is nondestructive and less time consuming than other common methods. A simple test pattern is proposed for evaluating the thickness on wafers in process. A comparison between this method and an IR-reflexion method (Digilab FTG 12) showed that both are in very good agreement in thickness range of  $2 \dots 6/\mu\text{m}$ .

**The experimental investigation of two-point spreading resistance correction factors for diffused layers**, N. Goldsmith, R. V. D'Aiello, and R. A. Sunshine, *SP400-10*, pp. 223-234 (June 1974).

Key words: correction factors; diffused layers; spreading resistance.

Spreading resistance measurements have been made on a series of  $\text{erfc}$  and Gaussian phosphorus diffusions into  $\text{n}$  and  $\text{p}$ -type silicon. Conventional four point probe methods were used to obtain values of sheet resistance and surface concentration. Comparison between the two methods shows increasingly large disagreements as the diffusion depth is decreased. The Dickey formula for accounting for the presence of a junction is shown to work well for uniform (nondiffused) samples but to fail to correct fully and properly for diffusions less than  $20 \mu\text{m}$  deep. Empiric curves for estimating errors on lapped surfaces used in this study are given for a wide variety of samples.

**Application of the spreading resistance technique to silicon characterization for process and device modeling**, W. H. Schroen, *SP400-10*, pp. 235-248 (June 1974).

Key words: arsenic; boron; design; device modeling; doping distribution; phosphorus; process control; process modeling; spreading resistance.

In recent years the interest in modeling of semiconductor processes and silicon device parameters has intensified considerably. Precise knowledge of the doping distribution in the semiconductor emerged as a key requirement for input and starting condition of many of these models and for their verification. It turned out that the spreading resistance technique, after careful probe calibration and multilayer data analysis, is able to supply some of the required data better than any other characterization technique available.



This paper discusses these successful applications. On the other hand, this paper points out inherent limitations of the spreading resistance technique with regard to resolution and precision, and how this affects the verification of process and device models. Finally, the paper describes ways to supplement the spreading resistance technique by other material characterization or electrical techniques so that the combination of these methods is capable of generating the required experimental data for the analytical models.

**Improved surface preparation for spreading resistance measurements on *p*-type silicon**, J. R. Ehrstein, *SP400-10*, pp. 249-256 (June 1974).

Key words: bevel polishing; *p*-type silicon; resistivity depth profiling; resistivity radial profiling; semiconductors; spreading resistance measurements; surface effects; surface preparation.

The interpretation and the precision of spreading resistance measurements have been seen to be strongly dependent on specimen surface preparation. A bakeout at 150 °C for 15 min following specimen surface preparation with any aqueous polishing solution is considered here. It is shown both to improve the precision of the basic calibration curve for spreading resistance measurements and to significantly improve the correlation between resistivity values derived from spreading resistance measurements on a variety of specimens, and resistivity values derived from other measurement techniques. No bakeout appears to be necessary if specimen surface preparation is done with a nonaqueous polishing process.

**SP401. Computer performance evaluation.** Proceedings of the Eighth Meeting of Computer Performance Evaluation Users Group [CPEUG], held at NBS, Gaithersburg, Md., December 4-7, 1973, H. J. Highland, Ed., Nat. Bur. Stand. (U.S.), Spec. Publ. 401, 155 pages (Sept. 1974) SD Catalog No. C13.10:401.

Key words: computer evaluation; computer performance; computer scheduling; hardware monitors; simulation of computer systems; software monitors; systems design and evaluation; time-sharing systems evaluation.

The Eighth Meeting of the Computer Performance Evaluation Users Group [CPEUG], sponsored by the United States Army Computer Systems Command and the National Bureau of Standards, was held December 4-7, 1973 at NBS, Gaithersburg. The program chairman for this meeting was Merton J. Batchelder of the U.S. Army Computer Systems Command at Fort Belvoir, Va. 22060 (CSCS-ATA Stop H-14).

About 150 attendees at this meeting heard the 17 papers presented on computer performance, evaluation and measurement. Among the papers presented were those dealing with hardware and software monitors, workload definition and benchmarking, a report of FIPS Task Force 13, computer scheduling and evaluation in time-sharing as well as MVT environment, human factors in performance analysis, dollar effectiveness in evaluation, simulation techniques in hardware allocation, a FEDSIM status report as well as other related topics.

These proceedings represent a major source in the limited literature on computer performance, evaluation and measurement. *These proceedings include the following papers (indented):*

**Getting started in computer performance evaluation**, P. J. Kiviat and M. F. Morris, *SP401*, pp. 5-13 (Sept. 1974).

**A methodology for performance measurement**, D. M. Venese, *SP401*, pp. 15-22 (Sept. 1974).

**Use of SMF data for performance analysis and resource ac-**

**counting on IBM large-scale computers**, R. E. Betz, *SP401*, pp. 23-32 (Sept. 1974).

**Using SMF and TFLOW for performance enhancement**, J. M. Graves, *SP401*, pp. 33-36 (Sept. 1974).

**USACSC software computer system performance monitor: SHERLOC**, P. Balcom and G. Cranson, *SP401*, pp. 37-43 (Sept. 1974).

**Benchmark evaluation of operating system software: Experiments on IBM's VS/2 system**, B. A. Ketchledge, *SP401*, pp. 45-48 (Sept. 1974).

**Report on FIPS Task Group 13 workload definition and benchmarking**, D. W. Lambert, *SP401*, pp. 49-53 (Sept. 1974).

**Performance measurement at USACSC**, R. Castle, *SP401*, pp. 55-62 (Sept. 1974).

**A computer design for measurement—the monitor register concept**, D. R. Deese, *SP401*, pp. 63-72 (Sept. 1974).

**The use of simulation in the solution of hardware allocation problems**, W. A. Hesser, *SP401*, pp. 73-79 (Sept. 1974).

**Human factors in computer performance analyses**, A. C. Shetler, *SP401*, pp. 81-84 (Sept. 1974).

**Dollar effectiveness evaluation of computing systems**, L. J. Cohen, *SP401*, pp. 85-98 (Sept. 1974).

**Computer scheduling in an MVT environment**, D. A. Verbois, *SP401*, pp. 99-97 (Sept. 1974).

**Performance evaluation of time sharing systems**, T. W. Potter, *SP401*, pp. 107-114 (Sept. 1974).

**A case study in monitoring the CDC 6700—a multi-programming, multi-processing, multi-mode system**, D. M. Conti, *SP401*, pp. 115-118 (Sept. 1974).

**FEDSIM status report**, M. F. Morris and P. J. Kiviat, *SP401*, pp. 119-122 (Sept. 1974).

**Data analysis techniques applied to performance measurement data**, G. P. Learmonth, *SP401*, pp. 123-126 (Sept. 1974).

**A simulation model of an AUTODIN automatic switching center communications data processor**, R. B. McManus, *SP401*, pp. 127-136 (Sept. 1974).

**SP404. Approaches to privacy and security in computer systems.** Proceedings of a Conference held at the National Bureau of Standards, Gaithersburg, Md., March 4-5, 1974, Clark R. Renninger, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 404, 84 pages (Sept. 1974) SD Catalog No. C13.10:404.

Key words: Computer systems; confidentiality; privacy; privacy and security; security.

This publication summarizes and contains the proceedings of a conference held at the National Bureau of Standards on March 4-5, 1974 to continue the dialog in search of ways to protect confidential information in computer systems.

Proposals are presented for meeting governmental needs in safeguarding individual privacy and data confidentiality that were identified at a conference held in November 1973. Among the proposals are the enactment of privacy legislation, improved computer system architecture and access controls, information and security management guidelines and the development of a systematic, balanced approach to system security.

The proposals were presented by legislators, citizens, computer industry associations and companies, professional societies, and public interest groups. *These proceedings include the following papers (indented):*

**The privacy issue**, A. R. Miller, *SP404*, pp. 2-3 (Sept. 1974).

**Current legislative proposals in Congress**, E. I. Koch, *SP404*, pp. 3-4 (Sept. 1974).

**Current legislative proposals in Congress**, B. M. Goldwater, Jr., *SP404*, pp. 5-6 (Sept. 1974).

**A citizen's view of the privacy issue**, J. L. Hardaway, *SP404*, pp. 6-8 (Sept. 1974).

**The issues of privacy and computer security within the State of Ohio**, S. J. Aronoff, *SP404*, pp. 8-10 (Sept. 1974).

**The issues of privacy and computer security within the State of California**, M. Cullen, *SP404*, pp. 10-14 (Sept. 1974).

**The issues of privacy and computer security within the State of Massachusetts**, A. R. Miller, *SP404*, pp. 14-15 (Sept. 1974).

**The views of the computer and business equipment manufacturers association (CBEMA)**, P. McCloskey, *SP404*, pp. 16-19 (Sept. 1974).

**A call for non-proprietary security systems**, A. C. W. Biddle, *SP404*, pp. 19-20 (Sept. 1974).

**The views of the association of data processing service organizations**, J. B. Christiansen, *SP404*, pp. 21-22 (Sept. 1974).

**The professional aspects of privacy and confidentiality**, R. W. Rector, *SP404*, pp. 22-24 (Sept. 1974).

**Data processing management association statement on privacy and security in computer systems**, D. W. Sanford, *SP404*, pp. 25-26 (Sept. 1974).

**A systematic approach to data security**, R. L. Thomas and R. H. Courtney, *SP404*, pp. 26-32 (Sept. 1974).

**Security in computer networks**, P. S. Browne, *SP404*, pp. 32-37 (Sept. 1974).

**Computer system architecture and access controls**, O. R. Smoot, *SP404*, p. 37 (Sept. 1974).

**Security architecture using encryption**, R. R. Keys and E. H. Clamons, *SP404*, pp. 37-41 (Sept. 1974).

**Access controls in Burroughs large systems**, H. W. Bingham, *SP404*, pp. 42-45 (Sept. 1974).

**Systems architecture for security and protection**, J. P. Anderson, *SP404*, pp. 45-50 (Sept. 1974).

**Pragmatic approaches to software security**, R. L. Caplan, *SP404*, pp. 50-53 (Sept. 1974).

**Information and security management**, J. F. Cunningham, *SP404*, pp. 53-54 (Sept. 1974).

**Risk analysis in planning for physical security**, R. V. Jacobson, *SP404*, pp. 54-55 (Sept. 1974).

**Security considerations in information systems design**, S. B. Lipner, *SP404*, pp. 55-59 (Sept. 1974).

**Auditing current systems**, D. B. Parker, *SP404*, pp. 59-61 (Sept. 1974).

**The medical patient's right to privacy**, L. A. Bowden, *SP404*, p. 62 (Sept. 1974).

**Confidentiality of the medical record**, M. Beard, *SP404*, p. 63 (Sept. 1974).

**Model legislation**, B. Backus, *SP404*, pp. 63-64 (Sept. 1974).

**On information files and people**, M. P. Kriger, *SP404*, pp. 64-65 (Sept. 1974).

**The need for privacy legislation**, R. H. Long, *SP404*, p. 65 (Sept. 1974).

**The administrative burdens of privacy legislation**, E. I. Golding, *SP404*, p. 66 (Sept. 1974).

**SP405. Benchmarking and workload definition: A selected bibliography with abstracts**, J. L. Walkowicz, Nat. Bur. Stand. (U.S.), Spec. Publ. 405, 46 pages (Nov. 1974) SD Catalog No. C13.10:405.

Key words: benchmarking; bibliography; computer performance measurement; computer procurement; workload definition.

These 85 citations to the literature of benchmarking and workload definition were selected from a longer list of documents, encompassing a somewhat broader scope, that was submitted to Federal Information Processing Standards (FIPS) Task Group 13 in response to a request made to attendees of the Task Group's Planning Session held on July 12, 1973, at the National Bureau of Standards. One of the topics discussed at the Planning Session was the collection of a selected bibliography on workload definition and benchmarking. The bibliographic effort was to be directed not so much toward exhaustiveness as toward the development of a bibliography that the attendees had found useful and would, therefore, recommend to other workers in the field. Of the approximately 250 citations submitted to the Task Group, these 85 were selected on the basis of two criteria: (1) the item dealt primarily with benchmarking or workload definition; and (2) hard copy was available at the Institute for Computer Sciences and Technology. The citations are arranged alphabetically by last names of the first authors. Each citation has an abstract, a classification category assignment, and a list of keywords. The category assignments are made from a classification scheme that was developed for the collection and that is used here as a Category Index to the Bibliography. A Keyword Index is also provided.

**SP409. Marine pollution monitoring (petroleum)**. Proceedings of a Symposium and Workshop Held at the National Bureau of Standards, Gaithersburg, Md., May 13-17, 1974, R. C. Junghans, Conference Coordinator, Nat. Bur. Stand. (U.S.), Spec. Publ. 409, 293 pages (Dec. 1974) SD Catalog No. C13.10:409.

Key words: analytical methods; data reporting procedures; Intergovernmental Oceanographic Commission (IOC); marine pollution (petroleum) monitoring; Maritime Administration (MarAd); National Bureau of Standards (NBS); National Oceanic and Atmospheric Administration (NOAA); oil slicks and tar balls; petroleum hydrocarbon measurement; sampling methods; World Meteorological Organization (WMO).

These proceedings contain the invited plenary lectures representing pertinent scientific, environmental, and regulatory aspects of petroleum hydrocarbon measurements, the summaries of the contributed papers, dealing with specific scientific developments and recommendations, and the recommendations of the topical discussion groups. Also included is a report of an international workshop which provides specific recommendations for the initiation of a coordinated Pilot Project for marine pollution (petroleum) monitoring. *These proceedings include the following papers (indented):*



**United Nations environment program Earthwatch and marine pollution**, R. M. White, *SP409*, pp. 3-7 (Dec. 1974).

**Scientific problems of the systems for global monitoring and investigation of oil pollution in the world ocean**, A. I. Simonov, *SP409*, pp. 9-14 (Dec. 1974).

**Environmental quality**, B. E. Willard, *SP409*, pp. 15-18 (Dec. 1974).

**Comments**, P. Thatcher, *SP409*, pp. 19-20 (Dec. 1974).

**Pilot project on marine pollution monitoring under the framework of IGOSS**, A. Tolkachev, *SP409*, pp. 21-26 (Dec. 1974).

**Survey analyses for petroleum derived hydrocarbons in the ocean**, S. Hori, *SP409*, pp. 27-28 (Dec. 1974).

**Analysis standards and intercomparison of data**, S. R. Galler, *SP409*, pp. 29-31 (Dec. 1974).

**Maritime consideration of oil transportation**, H. F. Casey, *SP409*, pp. 33-39 (Dec. 1974).

**Marine pollution data archiving and exchange**, R. M. Morse, *SP409*, pp. 41-49 (Dec. 1974).

**Biological environmental effects**, M. E. Stansby, *SP409*, pp. 45-48 (Dec. 1974).

**Maritime considerations**, J. J. Nachtsheim, *SP409*, pp. 49-56 (Dec. 1974).

**Regulatory functions**, T. A. Wastler, *SP409*, pp. 57-59 (Dec. 1974).

**Regulatory functions as related to vessel construction and operation**, S. A. Wallace, *SP409*, pp. 61-65 (Dec. 1974).

**Quantitative monitoring and variability of pelagic tar in the North Atlantic**, J. N. Butler and B. F. Morris, *SP409*, pp. 75-58 (Dec. 1974).

**Tar ball loadings on Golden Beach, Florida**, W. A. Saner, *SP409*, pp. 79-81 (Dec. 1974).

**Tar ball sampling in the western North Atlantic**, W. E. McGowan, W. A. Saner, and G. L. Hufford, *SP409*, pp. 83-84 (Dec. 1974).

**Evaluation of thin film oil samplers**, W. J. Chang and J. R. Jadamec, *SP409*, pp. 85-88 (Dec. 1974).

**Oil spillage monitoring, sampling and recovery systems**, J. G. Zahka, *SP409*, pp. 89-90 (Dec. 1974).

**Sampling of oil spills and fingerprinting by infrared spectroscopy**, C. W. Brown, M. Ahmadjian, and P. Lynch, *SP409*, pp. 91-92 (Dec. 1974).

**A new infrared instrument for monitoring oil films on water**, D. E. Wright and J. A. Wright, *SP409*, pp. 93-94 (Dec. 1974).

**Mapping and identification of oil on water by the use of an airborne laser system**, G. K. Schwemmer and H. H. Kim, *SP409*, pp. 95-96 (Dec. 1974).

**Movement of spilled oil in San Francisco Bay as predicted by estuarine nontidal drift**, T. J. Conomos, *SP409*, pp. 97-100 (Dec. 1974).

**Oil pollution along the Indian coastline**, S. N. Dwivedi and A. H. Parulekar, *SP409*, pp. 101-105 (Dec. 1974).

**Sampling errors in the quantitation of petroleum in Boston Harbor water**, A. M. Ahmed, M. D. Beasley, A. C. Efromson, and R. A. Hites, *SP409*, pp. 109-111 (Dec. 1974).

**Hydrocarbon concentrations in seawater along the Halifax-Bermuda section: Lessons learned regarding sampling and some results**, D. C. Gordon, Jr., and P. D. Keizer, *SP409*, pp. 113-115 (Dec. 1974).

**Determination of aromatic hydrocarbons in sea water using an electrolytic stripping cell**, S. P. Wasik and R. N. Boyd, *SP409*, pp. 117-118 (Dec. 1974).

**Determination of aromatic and total hydrocarbon content in submicrogram and microgram quantities in aqueous systems by means of high performance liquid chromatography**, A. Zsolnay, *SP409*, pp. 119-120 (Dec. 1974).

**Determination of C<sub>1</sub> - C<sub>10</sub> hydrocarbons in water**, C. D. McAuliffe, *SP409*, pp. 121-125 (Dec. 1974).

**Suspensions of crude oils in sea water: Rapid methods of characterizing light hydrocarbon solutes**, R. M. Bean, *SP409*, pp. 127-130 (Dec. 1974).

**Measurement and characterization of nonvolatile hydrocarbons in ocean water**, R. A. Brown, J. J. Elliott, and T. D. Searl, *SP409*, pp. 131-133 (Dec. 1974).

**Identification, estimation and monitoring of petroleum in marine waters by luminescence methods**, A. W. Hornig, *SP409*, pp. 135-144 (Dec. 1974).

**Recent developments in the identification of asphalts and other petroleum products**, F. K. Kawahara, *SP409*, pp. 145-148 (Dec. 1974).

**Identification of hydrocarbons in an extract from estuarine water accommodated No. 2 fuel oil**, R. H. Bieri, A. L. Walker, B. W. Lewis, G. Losser, and R. J. Huggett, *SP409*, pp. 149-153 (Dec. 1974).

**The role of standard reference materials in environmental monitoring**, H. T. Yolken, *SP409*, pp. 157-160 (Dec. 1974).

**Standard and intercomparison criteria: Tar balls and particulate matter**, R. W. Traxler and R. H. Pierce, Jr., *SP409*, pp. 161-162 (Dec. 1974).

**Analyses of hydrocarbons in marine organisms: Results of IDOE intercalibration exercises**, J. W. Farrington, J. M. Teal, J. G. Quinn, P. L. Parker, J. K. Winters, T. L. Wade, and K. Burns, *SP409*, pp. 163-166 (Dec. 1974).

**IDOE-5 intercalibration sample: Results of analysis after sixteen months storage**, G. C. Medeiros and J. W. Farrington, *SP409*, pp. 167-169 (Dec. 1974).

**Use of low molecular-weight-hydrocarbon concentrations as indicators of marine pollution**, W. M. Sackett and J. M. Brooks, *SP409*, pp. 171-173 (Dec. 1974).

**Fluorescence monitoring study at ocean weather station "P"**, W. J. Cretney and C. S. Wong, *SP409*, pp. 175-177 (Dec. 1974).

**Sampling marine organisms and sediments for high precision gas chromatographic analysis of aromatic hydrocarbons**, H. E. Bruce and S. P. Cram, *SP409*, pp. 181-182 (Dec. 1974).

**Field sampling methods and techniques for marine organisms and sediments**, D. Straughan, *SP409*, pp. 183-187 (Dec. 1974).

**Methods for establishing levels of petroleum contamination in organisms and sediment as related to marine pollution monitoring**, R. C. Clark, Jr., *SP409*, pp. 189-194 (Dec. 1974).

**Quantitative determination of hydrocarbons in marine organisms**, J. S. Warner, *SP409*, pp. 195-196 (Dec. 1974).

**Methods for trace organic analysis in sediments and marine organisms**, H. S. Hertz, S. N. Chesler, W. E. May, B. H. Gump, D. P. Enagonio, and S. P. Cram, *SP409*, pp. 197-199 (Dec. 1974).

**Long term weathering characteristics of Iranian crude oil: The wreck of the "Northern Gulf"**, D. W. Mayo, D. J. Donovan, L. Jiang, R. L. Dow, and J. W. Hurst, Jr., *SP409*, pp. 201-208 (Dec. 1974).

**Analytical techniques for isolating and quantifying petroleum paraffin hydrocarbons in marine organisms**, R. C. Clark, Jr., and J. S. Finley, *SP409*, pp. 209-212 (Dec. 1974).

**Determination of hydrocarbons in marine organisms and sediments by thin layer chromatography**, L. Hunter, H. E. Guard, and L. H. DiSalvo, *SP409*, pp. 213-216 (Dec. 1974).

**Determination of extractable organic material and analysis of hydrocarbon types in lake and coastal sediments**, J. W. Blaylock, R. M. Bean, and R. E. Wildung, *SP409*, pp. 217-219 (Dec. 1974).

**Hydrocarbons in blue mussels from the Kiel Bight**, M. Ehrhardt and J. Heinemann, *SP409*, pp. 221-225 (Dec. 1974).

**Identification of mineral oils by field ionization mass spectrometry**, M. Anbar, M. E. Scolnick, and A. C. Scott, *SP409*, pp. 229-232 (Dec. 1974).

**Pelagic tar in the Gulf of Mexico and Caribbean Sea**, L. M. Jeffrey, W. E. Pequegnat, E. A. Kennedy, A. Vos, and B. M. James, *SP409*, pp. 233-235 (Dec. 1974).

**Marine environmental monitoring: Trace elements in persistent tar ball oil residues**, M. H. Feldman and D. E. Cawfield, *SP409*, pp. 237-241 (Dec. 1974).

**Distribution of tar balls and Neuston sampling in the Gulf Stream system**, K. Sherman, J. B. Colton, R. L. Dryfoos, K. D. Knapp, and B. S. Kinneary, *SP409*, pp. 243-244 (Dec. 1974).

**Estimation of the modern oil pollution of the North Atlantic Waters**, A. I. Simonov, S. G. Oradovski, and A. A. Justchak, *SP409*, p. 245 (Dec. 1974).

**Value of oil pollution monitoring in marine organisms**, G. La Roche, *SP409*, pp. 249-250 (Dec. 1974).

**Effects of oils on Baltic Littoral Community, as studied in an outdoor model test system**, M. Notini and Å. Hagström, *SP409*, pp. 251-254 (Dec. 1974).

**Hydrocarbon content and chlorophyll correlation in the waters between Nova Scotia and the Gulf Stream**, A. Zsolnay, *SP409*, pp. 255-256 (Dec. 1974).

**Effect of an oil spill on benthic animals in the lower York River, Virginia**, M. E. Bender, J. L. Hyland, and T. K. Duncan, *SP409*, pp. 257-259 (Dec. 1974).

**Marine pollution by carcinogenic hydrocarbons**, J. B. Sullivan, *SP409*, pp. 261-263 (Dec. 1974).

**SP411. Fire safety research.** Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, Md., August 22, 1973, M. J. Butler and J. A. Slater, Eds., Nat. Bur. Stand. (U.S.), Spec. Publ. 411, 251 pages (Nov. 1974).

**Key words:** children; flammable fabrics; sleepwear; standards development; statistics.

The general methodology used in the development of a mandatory flammability Standard is presented. An illustrative summary is given of the hazard analysis of the accident data and the subsequent test development and laboratory investigations conducted in the development of the children's sleepwear flamma-

bility standards (DOC FF-3-71 and DOC PFF 5-73). Some of the problems encountered in the development of a mandatory standard and the resolution of those problems are discussed.

**A comparison between potential hazard reduction from fabric flammability standards, ignition source improvement and public education**, B. Buchbinder and A. Vickers, *SP411*, pp. 1-4 (Nov. 1974).

**Key words:** cigarettes; education; fabric; fire; flammability; hazard; ignition source; kitchen ranges; matches; mattresses; sleepwear; standards; upholstered furniture.

Mandatory standards have been and are being promulgated for flammable fabric item types (e.g., children's sleepwear, mattresses, upholstered furniture) to reduce the fire hazard inherent in the use of common ignition sources (e.g., matches, cigarettes, kitchen ranges). Trade-offs should be made between potential hazard reduction from fabric item standards and from design changes or improved quality control in ignition source fabrication. Public education is a third approach to the reduction of certain hazards.

**Development of the standards for the flammability of children's sleepwear**, E. Braun, J. H. Winger, and J. A. Slater, *SP411*, pp. 5-16 (Nov. 1974).

**Key words:** children; flammable fabrics; sleepwear; standards development; statistics.

The general methodology used in the development of a mandatory flammability Standard is presented. An illustrative summary is given of the hazard analysis of the accident data and the subsequent test development and laboratory investigations conducted in the development of the children's sleepwear flammability standards (DOC FF-3-71 and DOC PFF-5-73). Some of the problems encountered in the development of a mandatory standard and the resolution of those problems are discussed.

**Sampling plans in mandatory standards**, P. Gottfried, *SP411*, pp. 16-19 (Nov. 1974).

**Key words:** flammable fabrics; product safety; sampling; standards.

The Children's Sleepwear Standard for sizes 0-6X provides an example of the necessary interplay between sampling theory, industry capabilities and consumer safety assurance. The sampling plan imposes requirements for the fabric, for garment design and for garment production. These requirements address the differences between hazards due to design and those due to production errors. The requirements also interact to provide improved assurance of safety by limiting the potential for severe injury.

**Human activity patterns and injury severity in fire incidents involving apparel**, L. B. Buchbinder, *SP411*, pp. 20-29 (Nov. 1974).

**Key words:** accident patterns; apparel; apparel fires; burn injury; FFACTS; fire; flammable fabrics; flammable liquids; garment fires; garment parameters; injury severity; victim's activity; victim's reactions.

Activities immediately preceding an apparel fire are identified, classified and related to the age/sex groups involved. The level of severity of burn injuries resulting from apparel fire accidents is discussed and is related to the type of activity causing the accident. The relationships defined in the study indicate the importance of the human behavioral aspects of a fire accident and aid in defining types of remedial action likely to be effective in reducing human loss due to fabric fires.

**Chemical aspects of flame inhibition**, J. W. Hastie, *SP411*, pp. 30-36 (Nov. 1974).



**Key words:** fire retardants; flames; inhibition.

The role played by inorganic chemical additives in fire retardancy and flame inhibition is considered. Particular attention is given to the molecular level aspects of commercially important systems containing compounds of antimony and halogens.

**Mechanism of flame retardant action in textiles,** R. H. Barker, *SP411*, pp. 37-49 (Nov. 1974).

**Key words:** calorimetry; cellulose; flames; flammable gases; nylon; oxidation reactions; oxygen index; phosphorus; polyester; polymer substrates; pyrolysis-gas chromatography; textiles; thermal analysis.

Flame retardants may exert their effect on textile materials by either modifying the pyrolysis reactions of the polymer substrates so that smaller quantities of flammable gases are produced or by interfering with the oxidation reactions in the flame. The modes of action for several common types of retardants on cellulose, nylon, and polyester have been determined by use of thermal analysis, pyrolysis-gas chromatography, oxygen index, and calorimetric techniques.

**Additional studies of the transfer of flame retardant effects with cellulosic fabrics,** B. Miller, *SP411*, pp. 50-58 (Nov. 1974).

**Key words:** cellulotics; cotton; DAP; fabric flammability; flame retardants; flammability; rayon; thermogravimetric analysis.

Burning rate measurements on double layers of the same fabric when one layer has been treated with a flame retardant have indicated that certain effects of the retardant can be transferred to the untreated layer. To learn more about the mode and chemistry of this phenomenon, a study of non-flaming combustion of cellulotics has been carried out on mixed systems using thermogravimetric analysis. By arranging to have untreated cotton physically separated from the flame retardant material during heating it was possible to determine that the transfer depends on a chemical process and is most likely the effect of a volatile product generated during heating. Data are presented also showing that rayon containing an alkoxy-phosphazene flame retardant does not transfer its flammability properties to untreated rayon.

**An evaluation of flame spread test methods for floor covering materials,** J. Quintiere and C. Huggett, *SP411*, pp. 59-89 (Nov. 1974).

**Key words:** corridor fires; fire test methods; flame spread; flammability tests; floor covering flammability; floor coverings.

Flammability properties of materials have traditionally been measured by small scale laboratory tests. The relationships between test results and performance in real fires have been largely inferred by intuition or subjective judgement. Flame spread test methods for floor covering materials are examined. Through full-scale fire experiments and laboratory studies the nature of the potential flame spread hazard of flooring materials is presented. The factors promoting flame spread in each test method are identified. Test method results are compared with relevant full-scale fire experiments involving floor covering materials in a corridor. An effort is made to relate test results, where possible, to the potential flame spread hazard of floor covering materials in building corridors and exitways.

**Mathematical modeling of radiant panel test methods,** J. A. Rockett, *SP411*, pp. 90-96 (Nov. 1974).

**Key words:** fire modeling; fire test methods; flame spread; test method.

Standard flame spread tests characterize complex physical phenomena by a relatively simple experiment. Analytic modeling of the standard test identifies the sample geometry and material properties controlling the test outcome. Systematic variation of the model parameters verifies the analytic model for many broad classes of test samples provided parameter values appropriate to each test are determined by independent measurements. In most cases the standard test is not a satisfactory way to quantify the important sample parameters. The standard test is a suitable way to verify the applicability of a particular model or set of analytic models for a particular sample. If sample parameters are independently determined, the applicable models may then be used for hazard determination.

**Flame spread over a porous surface under an external radiation field,** T. Kashiwagi, *SP411*, pp. 97-104 (Nov. 1974).

**Key words:** carpet flammability; flame spread; ignition.

Flame spread over carpet surfaces was studied under various constant external radiant fluxes from 0.4 to 1.2 W/cm<sup>2</sup>. Characteristics of ignition and flame spread including speed of spread and net heat release rate were measured. The results indicate that these values increase rapidly with increasing external radiant flux. It was also observed that there exists a minimum radiant flux necessary to sustain steady flame spread for each carpet. The underlayment of a carpet has a significant effect on ignition and flame spread speed for nylon carpets due to melting of fibers before flameover. However, this effect is negligible for low pile density acrylic carpets.

**Physiological and toxicological effects of the products of thermal decomposition from polymeric materials,** M. M. Birky, *SP411*, pp. 105-124 (Nov. 1974).

**Key words:** combustion; polymer; pyrolysis; smoke; specific optical density; toxic gases; toxicity.

A program that combines the capabilities of the College of Medicine and the College of Engineering of The University of Utah has been instituted to evaluate the physiological and toxicological effects of the products of thermal degradation and combustion of cellulose, a polyvinyl chloride, a flexible polyurethane, and wood (Douglas fir). The products produced from these materials are being identified and quantified with a gas chromatograph-mass spectrometer-computer system. In addition, a National Bureau of Standards smoke chamber has been modified with a weight loss transducer to correlate, on a continuous basis, the quantities of smoke produced with sample weight loss. Extensive studies on the effects of these degradation products on rats is in progress. The results of exposure of the rats to carbon monoxide are reported. All of the laboratory results are being correlated with full-scale fire studies at the National Bureau of Standards.

**Contribution of interior finish materials to fire growth in a room,** J. B. Fang and D. Gross, *SP411*, 125-138 (Nov. 1974).

**Key words:** buildings; fire intensity; flame spread; flames; furnishings; heat release; interior linings; material ignitability; room fires; smoke; upholstery; waste receptacle; wood crib.

Characterization of the fire environment from the burning of the combustible contents of wastebaskets, upholstered furniture and interior finish materials is important for developing rational tests and establishing design criteria for reduction of fire hazard in buildings. Some experimental results on the burning characteristics of an upholstered



chair, contents of waste receptacles and wood crib arrays in a well-ventilated room are presented. A procedure has been developed for evaluating the contribution to fire growth of wall and ceiling panels in a full-scale room corner with a standardized wood crib duplicating the conditions produced by an incidental fire. Results of full-scale and laboratory tests with selected interior finish materials on ease of ignition, surface flammability, flame penetration and smoke and heat generation measurements are presented and compared.

**Fire build-up in reduced size enclosures**, W. J. Parker and B. T. Lee, *SP411*, pp. 139-153 (Nov. 1974).

Key words: fire tests; flashover; heat release rate; scale models; thermal radiation.

A 30×30×32 inch enclosure was constructed to study the fire build-up process in a room. Conductive and radiative heat flux, temperature, air velocity, fuel supply rate, and oxygen concentration were measured. In order to relate the phenomena observed in the small enclosure to that in a full size room, the possibility of small-scale modeling with combustible walls was examined. This was done on a preliminary basis by comparing the results of some corner fire tests conducted both in the model and in a full size room. A preliminary examination was also made of the effect of the fuel flow rate and the location of the burner on the temperature and oxygen profiles in the enclosure. Since the ceiling temperature closely follows the upper air temperature the latter is a suitable measure of the degree of fire build-up in the room. Any analysis of the fire build-up process must account for this temperature.

**An analytic model for calculating the fire resistance of simply supported prestressed and reinforced concrete beams**, L. A. Isen, *SP411*, pp. 154-164 (Nov. 1964).

Key words: analytic methods; concrete; creep; elevated temperature; finite differences; finite elements; fire endurance; fire tests; isotherms; prestressed concrete; reinforced concrete; steel.

At present the fire resistance of concrete beams is determined either by running a fire test or by interpolation from existing fire test data. The second method can only be used if the data are for beams that are closely similar to the object beam. Other ad hoc empirical methods are equally limited. To overcome these difficulties an analytic model was developed for the rational analysis of prestressed and reinforced concrete beams. This model will be checked against available test data. A computer program based on the analytic model is being tested and will be used for developing graphical tools (graphs, nomograms, tables) for estimating the fire endurance of simply supported prestressed and reinforced concrete beams.

**Smoke and carbon monoxide generation from burning selected plastics and red oak**, T. Y. King, *SP411*, pp. 165-177 (Nov. 1974).

Key words: carbon monoxide; electrostatic precipitation; particulate mass; scanning electron microscope; smoke.

This paper presents preliminary results of simultaneous smoke and carbon monoxide measurements from burning selected plastics and red oak in the smoke density chamber. An attempt was made to correlate smoke optical density with mass concentration of smoke. Particulate shape and approximate size range of the smokes were obtained using a scanning electron microscope.

**A field study of non fire-resistive multiple dwelling fires**, F. L. Brannigan, *SP411*, pp. 178-194 (Nov. 1974).

Key words: apartments; building codes; fire; fire walls;

garden apartments; gypsum board; insurance; livability; multiple dwellings.

A field study was made of structural and building design factors contributing to the spread of fire in more than 40 non fire-resistive, multiple occupancy dwellings, typically "Garden Apartments." Most deficiencies could be corrected by preserving the integrity of a gypsum board sheath serving as a fire barrier. Examples are given of penetrations and openings in fire barriers which permitted substantial fire spread.

**The current status of fire detection**, G. Sinnott, *SP411*, pp. 195-200 (Nov. 1974).

Key words: alarm communications; false alarms; fire alarms; fire detectors; risk benefit; smoke detectors; standards.

The status of residential fire detection systems is presented in terms of the major problems encountered in their use. This includes a discussion of risk benefit considerations, false alarms, and the effectiveness of alarms. The impact of these considerations on acceptance standards for residential fire detection systems is pointed out.

**Sequencing the purchase and retirement of fire engines**, P. B. Saunders and R. Ku, *SP411*, pp. 201-214 (Nov. 1974).

Key words: dynamic programming; equipment replacement; fire engines.

A mathematical model and solution method are presented for the problem of determining an "optimum" manner of sequencing the purchase and retirement of fire engines. The method calculates that stream of "buy and retire" decisions which, subject to certain natural constraints (such as limits on annual acquisitions), minimizes the operating cost of the fleet of engines over a prescribed planning period. Implemented as an efficient computer program, the model has been applied to illustrative data from the Washington, D.C. Fire Department. The approach carries over to problems dealing with the replacement of other types of items (e.g., ambulances, small fleets of aircraft, typewriters) whose reliability-maintenance becomes increasingly expensive with age.

**FIFI—Fire information field investigation**, F. J. Kauffman and M. E. Grimes, *SP411*, pp. 215-229 (Nov. 1974).

Key words: field investigation; fire information; fire investigations; fire training; programmed instruction.

The Research Phase of FIFI defined and evaluated those state-of-the-art investigation techniques used at the scene of fires to report on the cause and circumstances of those fires. The two most significant conclusions reached during the research phase were (a) that very little literature is available to an officer interested in studying methods of general fire cause determination, since most existing literature is arson oriented, and (b) that standardized training programs in systematic investigative practices do not exist. The Development Phase of the project isolated the most valid of the investigative techniques evaluated in the research phase, and synthesized them into a new, simplified, logical, process-of-elimination investigation sequence known as HEP (Hexagonal Elimination Process) based on the NFPA Standard 901, *Coding System for Fire Reporting*. Two prototype training packages were developed; designed to aid firefighters in carrying out the systematic HEP investigation sequence in their initial, on-scene, routine fire investigations. The prototype training packages were field tested in six fire departments of varying sizes and types.

**National Science Foundation RANN Program**, R. H. Long, Jr., *SP411*, pp. 230-238 (Nov. 1974).



Key words: fire programs; fire research; National Science Foundation; RANN; research grants.

The fire research effort at NSF is part of the Research Applied to National Needs (RANN) Program of NSF, which provides funds for problem-oriented research on selected problems of national importance. The current effort is funded at \$2 million and about 20 projects are under way. An outline of the thrust of the total program will be given. Also, several projects which are closely related to interests of the National Bureau of Standards will be indicated. Related activities within NSF will be mentioned.

**SP412. Aerosol measurements.** The Proceedings of a Seminar on Aerosol Measurements, May 7, 1974, W. A. Cassatt and R. S. Maddock, Eds., Nat. Bur. Stand. (U.S.), Spec. Publ. 412, 193 pages (Oct. 1974) SD Catalog No. C13.10:412.

Key words: aerosol instrument performance; aerosol measuring instruments; beta-ray absorption; Doppler shift; electromobility; laser light scattering; optical imaging; piezoelectric effect.

Papers followed by discussions were given in a closed seminar and workshop sponsored by the National Bureau of Standards and the Food and Drug Administration to define the state of development of aerosol measuring instruments. The instruments discussed were based upon a variety of operating principles including laser light scattering, optical imaging, Doppler shift, electromobility, piezoelectric effect, and beta-ray absorption. Two review papers were given which described other phenomena upon which aerosol measurements are based. The general summary includes a table which lists the specifications of the instruments discussed to illustrate the range of capabilities available in this field. Discussion among seminar attendees revealed that many questions remain to be answered before the more difficult aerosol measurements problems can be solved. For example, in the analysis of very dense aerosols questions arise concerning coincidence losses or agglomeration effects that may result from collisions between particles as they are drawn into the measuring volume. Volatilization or condensation effects may alter the size distribution if the measurements are made late in time. Finally, variations in particle shape or index of refraction can alter the instrument response and cause difficulties in interpretation. *These proceedings include the following papers (indented):*

**A review of the methods for the particle size analysis of aerosol spray can droplets,** R. Davies and J. D. Stockham, *SP412*, pp. 1-12 (Oct. 1974).

Key words: aerosol instrumentation; aerosol measurements; aerosol review; aerosols; aerosol scattering; aerosol sizing; droplet imaging; droplet sizing; electrical mobility; impaction; momentum methods; particle imaging; particle measurements; particle scattering; particle size determinations; particulates; sprays.

This paper reviews the methods that have been used for sizing droplets, sprays, and mists, but places particular emphasis on the methods that are applicable to the sizing of aerosol spray can droplets.

The methods reviewed include photographic imaging, collection, deposition and size reconstruction, momentum transfer, pulse counting, hot wire anemometry, electrical mobility, optical scattering, and interference.

From the various techniques discussed in each class, laser holographic imaging is considered the best approach, but the method has an extremely high capital cost. Light scattering methods are the second choice, but these, too, have a relatively high capital cost. If capital cost is an important factor, then methods such as photographic imaging and impaction can be usefully employed.

**Light scattering by single aerosol particles,** M. Kerker, *SP412*, pp. 13-20 (Oct. 1974).

Key words: aerosol fibers; light scattering; particle size measurements; particulates; refractive index.

Although angular light scattering is a sensitive measure of particle size, sensitivity is rapidly lost when a mixture of particulates covers a range of particle sizes. However, instrumentation for studying scattering by single particles can overcome this limitation. This will be illustrated with reference to scattering by single fibers and spheres.

**Light scattering methods for the characterization of particulate matter in real time,** C. C. Gravatt, *SP412*, pp. 21-32 (Oct. 1974).

Key words: aerosol sizing; aerosol spectrometer; chemical characterization of particles; fire produced particles; laser light scattering by aerosols; particle size measurements; particulates; refractive index; smoke detector.

This paper presents a brief overview of new light scattering methods for the rapid characterization of particulate matter in air. An instrument has been developed which determines the size distribution of particulate matter in air in essentially real time by a forward lobe light scattering method. The basic concept involves the simultaneous measurement of the intensity of light scattered by a single particle at two small scattering angles. The ratio of the two intensities is a direct measure of the size and is fairly independent of the index of refraction of the particle. Numerical solutions of the Mie equations for spheres have indicated that the sizing error by this method is not greater than  $\pm 15$  percent for the range of particle sizes from 0.2 to 4  $\mu\text{m}$  for essentially all possible indices of refraction. In addition, it appears feasible to extend the lower limit of size determination to 0.05  $\mu\text{m}$  by the measurement of a single forward lobe intensity. Also, a technique has been developed which permits some degree of chemical characterization of particles, and which has been employed in a smoke detector capable of distinguishing between fire-produced and nonfire-produced aerosols.

**Flow apparatus for the characterization of aerosols,** M. B. Ranade, *SP412*, pp. 33-40 (Oct. 1974).

Key words: aerosol size measurements; aerosol spectrometer; aerosol sprays; condensation on aerosol droplets; evaporation of aerosol droplets; laser light scattering by aerosols; therapeutic aerosols.

A flow apparatus has been developed to enable the size measurement of liquid aerosols to be measured under defined conditions with the help of a light scattering technique. This apparatus was used to study the evaporative behavior of submicron aqueous aerosols during transportation in air. The apparatus is currently being used to characterize large ( $\sim 50 \mu\text{m}$ ) aerosol particles under sedimentation. Portable versions of the flow apparatus are presently under development to characterize acid mist droplets, and to investigate the characteristics of therapeutic aerosols.

**360° scattering diagrams from individual aerosols in a flowing stream,** T. R. Marshall, C. S. Parmenter, and M. Seaver, *SP412*, pp. 41-56 (Oct. 1974).

Key words: aerosol light scattering; aerosol size measurements; aerosol spectrometer; aerosol sprays; laser light scattering by aerosols; refractive index; scattering diagrams; 360° scattering by particles.

Nearly complete 360° scattering diagrams have been obtained from each of a large number of individual aerosols which stream in an air sheath through a laser beam. A computer analysis of diagrams from a "monodisperse" aerosol



(polystyrene spheres with mean diameter near  $1.2\ \mu\text{m}$ ) shows that *both* diameter and refractive index can be determined from each scattering diagram to compile a statistical characterization of the aerosol. Diameter precision is about 0.4 percent and the refractive index can be determined to within 0.7 percent.

The method is clearly a practical approach to routine characterization of aerosol sprays containing spherical particles whose diameters range from about  $0.3\ \mu\text{m}$  to at least  $20\ \mu\text{m}$ . The refractive index determination will reveal differences between particle composition and bulk composition of the parent material as well as composition changes during aging of aerosol sprays.

**Active scattering aerosol spectrometry**, R. G. Knollenberg, *SP412*, pp. 57-64 (Oct. 1974).

Key words: aerosol light scattering; aerosol sizing; aerosol spectrometer; cloud droplet measurements; interferometer; laser imaging of particles; laser light scattering by aerosols; particle size measurements.

An active scattering aerosol spectrometer is one that uses the active open cavity of a laser as the source of particle illumination. The interferometric aspects of the oscillating radiation illuminating the particles produces both forward and backward scattered radiation at all collecting angles. This, coupled with the fact that the collecting optics solid angle can be considerably greater than one steradian, and an extremely intense source, results in a system with an extremely high sensitivity, fully capable of sizing particles several hundred Angstroms diameter using solid state silicon detectors.

**Rapid measurement of droplet size distributions by optical heterodyne spectroscopy**, I. Chabay, *SP412*, pp. 65-72 (Oct. 1974).

Key words: aerosol cloud chamber; aerosol light scattering; aerosol size measurements; aerosol spectrometer; cloud droplet measurements; Doppler measurements of particle size; laser heterodyne; laser scattering by aerosol particles; particle sizing.

A new technique which allows rapid, direct determination of particle size distributions by measurement of the Doppler shift of laser light scattered by falling particles will be discussed. The technique has been successfully applied to the measurement of parameters associated with cloud droplet growth (from 1 to 10 micrometer radius) in a diffusion cloud chamber. Applications to other types of particles in the size range 0.5-50 micrometers radius will be pointed out.

**Measurements of aerosol size distributions with a laser Doppler velocimeter (LDV)**, W. J. Yanta, *SP412*, pp. 73-88 (Oct. 1974).

Key words: aerosol sizing; aerosol spectrometer; aerosol sprays; Doppler measurements of particle size; droplet sizing; interferometer; laser light scattering by aerosols; particle size measurements; particle velocity measurements.

A miniature wind tunnel has been built which together with the Laser Doppler Velocimeter (LDV) has been used to determine aerosol size distributions. In principle the LDV was used to measure the particle lag of individual aerosol particles as they were accelerated through a small supersonic nozzle. The measured velocity lag was then used in conjunction with numerical predictions to determine the particle size. An optical owl was used to determine the mean of the size distributions. The LDV measurements were in good agreement with the owl measurements.

**An optical transform technique for measuring the size dis-**

**tribution of particles in fluids**, A. McSweeney, *SP412*, pp. 89-96 (Oct. 1974).

Key words: aerosol light scattering; aerosol sizing; aerosol spectrometer; laser light scattering by aerosols; optical transform; particle size measurements.

Real-time inversion of the data obtained from the total diffraction pattern due to particles in a relatively large volume yields a measure of the size distribution of the particles. A significant advantage of this technique is that the sample volume may be large, removing the requirement for piping the sample through small tubes. This technique may be applied to particles in gases, in liquids, or on microscope slides.

**Sizing aerosols in real time by pulsing UV laser machine**, G. A. Hotham, *SP412*, pp. 97-126 (Oct. 1974).

Key words: aerosol impact studies; aerosol sizing; aerosol spectrometer; aerosol sprays; laser holography; laser imaging of particles.

A new laser machine will be described which utilizes a pulsing UV laser to produce "instantaneous" images of aerosol droplets on a TV screen in real time. With this instrument it is possible to measure from 0.3 to 1000 micrometers.

**Rapid respirable mass measurement**, L. Doemeny, G. Carson, and B. Almich, *SP412*, pp. 127-136 (Oct. 1974).

Key words: aerosol size measurements; beta absorption; cascade impactor; coal dust monitor; dust inhalation hazards; environmental sampler; respirable dust sampler.

The respirable mass concept of dust sampling will be used to introduce the GCA Corporation, beta absorption particulate aerosol sampler. NIOSH has extensively evaluated the GCA instrument as a coal dust monitor and is beginning to apply it to the sampling of other aerosols. The evaluation included mass loading, accuracy and environmental simulations. Other sampling methods which look promising will be discussed.

**Particulate mass measurement by piezoelectric crystal**, R. L. Chuan, *SP412*, pp. 137-148 (Oct. 1974).

Key words: aerosol sizing; cascade impactor; particle detection by impaction; particle size measurements; piezoelectric crystal; quartz crystal microscope.

An adhesive-coated quartz crystal working as the impaction surface capturing particulates from decelerating jets measures mass by frequency change, to a sensitivity of  $10^9\ \text{Hz gm}^{-1}$ . The scheme is applied to a number of working instruments which measure continuously and directly particulate mass concentration, and particulate mass distribution (by using the devices in a cascade).

**Development, calibration and application of size distribution instruments at the University of Minnesota**, V. A. Marple, *SP412*, pp. 149-173 (Oct. 1974).

Key words: aerosol electrical analyzer; aerosol generators; aerosol instrument calibration; aerosol size measurements; aerosol spectrometer; aerosol sprays; nuclei counters; particle generators; particle size measurements; particle size measurements by electromobility; particle standards.

Work with size distribution instruments has been in the areas of development, calibration, and application. Instruments have been developed in the area of particle size determination, such as the electrical aerosol analyzer, and in the area of monodisperse particle generation, such as the vibrating orifice generator and the differential mobility analyzer. These aerosol generators, along with new techniques, have



been used to calibrate a variety of aerosol measuring instruments such as optical particle counters, nuclei counters, and the electrical aerosol analyzer. These instruments have then been used to study a range of particle types, from fairly ideal particles such as atmospheric aerosols to very nonideal particles such as coal dust.

**SP414. Laser induced damage in optical materials: 1974.** Proceedings of a Symposium Sponsored by Office of Naval Research, The American Society for Testing and Materials, and by the National Bureau of Standards, May 22-23, 1974, NBS, Boulder, Colo., 80302, A. J. Glass and A. H. Guenther, Eds., Nat. Bur. Stand. (U.S.), Spec. Publ. 414, 256 pages (Dec. 1974) SD Catalog No. C13.10:414.

**Key words:** IR windows and mirrors; laser damage; laser materials; self-focusing; thin films.

The Sixth ASTM-ONR-NBS Symposium on Laser Induced Damage in Optical Materials was held at the National Bureau of Standards in Boulder, Colo., on May 22-23, of this year. These Symposia are held as part of the activities in Subcommittee II on Lasers and Laser Materials, of the ASTM. Subcommittee II is charged with the responsibilities of formulating standards and test procedures for laser materials, components, and devices. The Chairman of Subcommittee II is Haynes Lee, of Owens-Illinois, Inc. Co-chairmen for the Damage Symposia are Dr. Arthur Guenther, Chief Scientist of the Air Force Weapons Laboratory, and Dr. Alexander J. Glass, Head, Theoretical Studies, Y Division, Lawrence Livermore Laboratory.

Over 150 attendees at the Symposium heard 31 papers on topics relating to laser induced damage in crystalline and non-linear optical materials, at dielectric surfaces, and in thin film coatings as well as discussions of damage problems in the infrared region due both to cw and pulsed irradiation. In addition, several reports on the theoretical analysis of laser-materials interaction relative to the damage process were given, along with tabulations of fundamental materials properties of importance in evaluation of optical material response to high power laser radiation. Attention was given to high power laser system design considerations which relate to improved system performance and reliability when various damage mechanisms are operable in such systems.

Because of the growing importance and acceptance of machined components in high power laser systems, a workshop on the machining of optics was held, under the coordination of Captain T. T. Saito of the Air Force Weapons Laboratory. Nine papers on various facets of the topic were presented dealing with machining procedures, surface characterization of machined elements, coating of machined components, and the polishing and damage resistance of polished, coated, and bare metal reflectors. Abstracts on these papers are included in the Symposium Proceedings proper.

The proceedings of these Symposia represent the major sources of information in the field of laser induced damage in optical materials. The Symposia themselves, along with the periodic meetings of Subcommittee II, provide a unique forum for the exchange of information regarding laser materials specifications among the manufacturers and users of laser devices, components, and systems. The Symposia also serve as a mechanism of information gathering to enable the Subcommittee to write informed and realistic specifications. *These proceedings include the following papers (indented):*

**Laser beam divergence and damage in glass amplifiers,** K. A. Brueckner, B. Guscott, S. Jorna, K. Moncur, and L. Siebert, *SP414*, pp. 2-6 (Dec. 1974).

**Key words:** apodizers; glass lasers; self-focusing.

The power limit in glass amplifiers is determined by the onset of nonacceptable beam distortion of self-focusing leading to glass damage, which results from the power-de-

pendent index in the glass. Self-phase modulation due to the variation of index with power also can at very high power result in pulse distortion and gain loss. These effects can be analyzed quantitatively by integration of Maxwell's equations together with the equation for gain variation of the lasing medium. Under conditions of rapid intensity change, diffraction effects can be ignored and the eikonal equation used to determine beam propagation.

To study these problems for small amplitude disturbances we have analyzed the equations using dispersion theory. For larger amplitudes we have developed several computer codes which allow exact simulation of the laser system and of selected components which are essential for control of the beam intensity.

The intensity of the laser beam must be carefully controlled to avoid both large scale and small scale effects. The large scale effects which increase beam divergence result from the initial beam radial intensity variation combined with nonuniform gain in the laser amplifiers. The small scale effects usually result from diffraction and interference and can be minimized by reducing interference effects as far as possible. This can best be done by the use of graduated or "soft" apertures placed at critical points in the beam. The beam intensity profile can also be controlled by the use of attenuators with graduated transmission.

These techniques offer highly flexible and effective control of the laser beam and allow operation well above 5 GW/cm<sup>2</sup>.

**Nonlinear propagation studies,** E. S. Bliss, *SP414*, pp. 7-16 (Dec. 1974).

**Key words:** apodization; beam breakup; instability theory; nonlinear propagation; propagation codes; self-focusing.

The desire to avoid damaging the components of high-power solid-state laser-systems being built for laser fusion experiments has led to increased interest in all aspects of intense pulse propagation. This paper describes a variety of observations of nonlinear propagation phenomena and the instrumentation used for measuring them, presents comparisons with theoretical predictions, and outlines some approaches to minimization of the resulting problems in large systems. The intent of the paper is to present an up-to-date summary of the progress being made in characterizing and controlling nonlinear propagation effects.

**Suppression of parasitic oscillation in laser rod amplifiers,** J. M. McMahon, R. P. Burns, and T. H. DeRieux, *SP414*, pp. 17-22 (Dec. 1974).

**Key words:** disc lasers; laser amplifiers; laser design; parasitic suppression.

The most common glass laser rod amplifier geometry is one in which the laser rod is centered in glass water jacket and pumped by Xenon flashlamps surrounding the water jacket. By suppressing parasitic modes in the amplifier much higher gains can be realized than previously achieved with a consequent increase in the short pulse damage threshold. 30-50 percent improvements have been attained in the NRL system and factor of two improvements are possible.

**Optical requirements for laser mirrors,** H. E. Bennett and P. C. Archibald, *SP414*, pp. 23-30 (Dec. 1974).

**Key words:** infrared absorption; laser damage; laser mirror; laser optical train; laser window; microroughness; optical figure; scattered light.

The surface and coating requirements for mirrors used in laser systems are very severe. They may be summarized as follows: (1) excellent figure under thermal load, (2) high catastrophic damage threshold and an absence of localized



sites where damage is likely to occur, and (3) low scattering levels. Backscattering is particularly important since it can easily damage the laser itself. The figure requirements for components increase rapidly when multicomponent "real world" optical trains are used. For example, to satisfy Maréchal's criterion for a 10 component system used at a wavelength of  $3.8\ \mu\text{m}$ , each component must have an initial figure of approximately 1/8th wave in the visible region and thermal distortion over the surface of less than  $1000\ \text{\AA}$ . Very high reflectance coatings with excellent uniformity are thus required. Light scattering at short wavelengths provides a powerful, nondestructive tool for measuring microroughness (which reduces the infrared reflectance of metal coatings), and for identifying potential sites where damage is likely to occur. The damage threshold of a metal mirror is not necessarily determined by its absorption, and our understanding of the laser mirror problem is still incomplete.

**Diffraction theory of absorbing windows**, M. Flannery and J. Marburger, *SP414*, pp. 31-38 (Dec. 1974).

Key words: birefringence; laser windows; thermal distortion.

The diffraction-optical theory of coherent polarized beams incident on realistic absorbing windows is developed here with emphasis on tracing the origin of qualitative features of the diffraction field. The influence of incident polarization, stress induced birefringence, and other parameters, on the transmitted beam is described, and both analytical and numerical solutions for the transmitted diffraction field are presented. Our development of the theory allows the influence of the window material to be characterized by two parameters in the transient regime rather than the three previously believed to be necessary. Implications for IR window design are summarized.

**Damage resistance of dielectric reflectors for picosecond pulses**, B. E. Newnam, *SP414*, pp. 39-47 (Dec. 1974).

Key words: damage thresholds; dielectric reflector; laser-induced scatter; picosecond pulses; spark thresholds; thin films; weak-signal scatter.

A state-of-the-art survey has been conducted to determine the range of damage thresholds of electron-gun-produced dielectric reflectors irradiated by 30-ps laser pulses at  $1.06\ \mu\text{m}$ . Seven commercial coating companies, experienced in producing refractory-oxide coatings, supplied total reflectors of a specified  $\text{TiO}_2/\text{SiO}_2$  design deposited on low-scatter glass substrates provided by LASL. Optional reflectors of  $\text{ZrO}_2/\text{SiO}_2$  were also evaluated. Single-shot thresholds were determined by laser-induced scatter and photoelectric detection of spark radiation. Thresholds of  $\text{TiO}_2/\text{SiO}_2$  reflectors ranged from 1 to  $4\ \text{J}/\text{cm}^2$ ; those for  $\text{ZrO}_2/\text{SiO}_2$  reflectors ranged from  $0.5$  to  $2\ \text{J}/\text{cm}^2$ . Reflectors which exhibited a large amount of diffuse, weak-signal scatter generally had low thresholds.

**Damage studies at  $1.06\ \mu\text{m}$  with 100-200 ps pulses**, G. W. Leppelmeier and M. Finkelstein, *SP414*, pp. 48-52 (Dec. 1974).

Key words: laser damage; mirror damage; thin films.

Studies have been conducted of the damage threshold at  $1.06\ \mu\text{m}$  of multilayer dielectric films used as polarizing beamsplitters, mirrors, and anti-reflection coatings,  $\text{K}(\text{H}_x\text{D}_{2-x})\text{PO}_4$ , several high Verdet constant glasses, and micromachined silver. The laser pulse used had less than 4 percent spatial and temporal ripple. Pulse energy of up to 1 joule permitted using a collimated beam. Damage thresholds in the range  $1$ - $5\ \text{J}/\text{cm}^2$  were obtained.

**Damage thresholds in ZnSe, A/R coated NaCl and micromachined mirrors by  $10.6\ \mu\text{m}$  multijoule, nanosecond pulses**, E. E. Stark, Jr., and W. H. Reichelt, *SP414*, pp. 53-58 (Dec. 1974).

Key words: A/R coatings; damage thresholds; machined mirrors; ZnSe.

Multijoule, nanosecond pulses at  $10.6\ \mu\text{m}$  were used to determine the damage thresholds of uncoated and antireflection (A/R) coated ZnSe, A/R coated NaCl and micromachined mirrors. The ZnSe results indicate that the A/R coatings have a higher damage threshold than the bulk material. Antireflection coatings on NaCl were found to have a damage threshold slightly lower than uncoated NaCl. Damage thresholds for micromachined copper and gold are greater than  $4\ \text{joules}/\text{cm}^2$ .

**Pulsed  $\text{CO}_2$  laser damage in windows, reflectors, and coatings**, V. Wang, J. E. Rudisill, C. R. Giuliano, M. Braunstein, and A. Braunstein, *SP414*, pp. 59-65 (Dec. 1974).

Key words:  $\text{As}_2\text{S}_3$ ; laser coatings; laser reflectors; laser windows; pulsed  $\text{CO}_2$  laser damage,  $\text{ThF}_4$ ; ZnSe.

Recent  $10.6\ \mu\text{m}$  damage measurements using a  $\text{TEM}_{00}$  laser of  $0.6\ \mu\text{sec}$  pulse length are reported for a variety of windows, reflectors, and coatings. Reduction of the density of inclusions in ZnSe was found to have a large effect upon scatter but a smaller effect upon damage resistance. Absorptions and damage thresholds of thin films of ZnSe,  $\text{As}_2\text{S}_3$  and  $\text{ThF}_4$  were measured upon relatively defect-free KCl substrates, and then tested in antireflection and multilayer reflector configurations. Also reported is a five-fold increase in damage resistance of simple polished copper reflectors by surface etching.

**Pulsed  $\text{CO}_2$  laser damage studies of RAP grown KCl**, S. D. Allen, M. Braunstein, C. Giuliano, and V. Wang, *SP414*, pp. 66-75 (Dec. 1974).

Key words: etch-polishing; KCl; laser damage; laser windows; RAP;  $10.6\ \mu\text{m}$ .

Laser damage thresholds in high purity RAP (Reactive Atmosphere Processing) KCl were measured as a function of surface and bulk processing techniques. Single crystal and press forged material was prepared in a "conventionally" polished and HCl etch-polished manner and the bulk and surface damage thresholds measured and correlated with absorption (cw  $\text{CO}_2$  laser calorimeter), Auger, LEED and SEM data. The damage measurements were made with a  $\text{TEM}_{00}$   $\text{CO}_2$  TEA laser with a  $0.6\ \mu\text{sec}$  pulse length.

**A comparison of  $10.6\ \mu\text{m}$  pulsed laser damage in sputtered vs electron beam deposited Ge-coated KCl**, A. Golubovic, W. Ewing, J. Bruce, J. Comer, and D. Milan, *SP414*, pp. 76-84 (Dec. 1974).

Key words: characterization of laser damage; e-beam deposition of germanium; germanium coating; laser damage mechanism; laser induced damage; multiple beam damage apparatus; potassium chloride; sputtering of germanium.

Germanium films deposited on KCl substrates by electron beam and sputter techniques have been irradiated at  $10.6\ \mu\text{m}$ . A comparative damage study of germanium films prepared by these techniques under pulsed irradiation is reported. A novel multiple beam pulsed laser damage apparatus was used for this study. Well characterized RAP Bridgman and Czochralski grown KCl substrates with (100) and (111) orientation were used.

**$10.6\ \mu\text{m}$  pulsed laser damage in ZnSe**, H. Posen, J. Bruce, and D. Milan, *SP414*, pp. 85-92 (Dec. 1974).



**Key words:** CO<sub>2</sub> pulsed laser damage; damage threshold; laser windows; twin structure; zinc selenide.

The effect of 10.6  $\mu\text{m}$  pulsed laser radiation on large grain ZnSe is examined with respect to the local crystallography of the material. In particular, the presence of twin boundaries, a common defect in II-VI materials, is shown to have very little effect on the damage threshold. Damage effects were monitored by Nomarski interference contrast microscopy, electron microscopy and x-ray topography.

**Evaluation of single crystal LaCl<sub>3</sub> AS CO<sub>2</sub> laser window material,** F. Varsanyi and L. G. DeShazer, *SP414*, p. 93 (Dec. 1974).

**Key words:** absorption coefficient; infrared materials; LaCl<sub>3</sub> thin film material.

We report calorimetric measurements of the LaCl<sub>3</sub> absorption coefficient at 10.6  $\mu\text{m}$ . Single crystal LaCl<sub>3</sub> of substantial size (one inch diameter, two or more inches long) were grown repeatedly in our laboratories in the past years, mostly for spectroscopic purposes. LaCl<sub>3</sub> is transparent in the visible extending up to 25  $\mu\text{m}$  and, if pure, is only slightly hygroscopic. Its phonon spectrum has been well investigated and terminates around 260  $\text{cm}^{-1}$ . A rather elaborate program of mechanical and optical property evaluation was initiated. In the preliminary experiments reported here, we studied a LaCl<sub>3</sub> single crystal ( $2 \times 11 \times 12$  mm) with a CO<sub>2</sub> laser. We feel LaCl<sub>3</sub> compares favorably with KCl as a laser window material, but without some of its problems.

**Laser window damage from CW 10.6- $\mu\text{m}$  radiation,** J. S. Loomis and C. A. Huguley, *SP414*, pp. 94-102 (Dec. 1974).

**Key words:** CO<sub>2</sub> laser radiation; CW laser damage; infrared windows; KCl; NaCl; optical distortion; ZnSe.

Damage studies have been conducted using a CW, one-kilowatt CO<sub>2</sub> laser. Some analytic calculation of local temperature rise as a function of laser power, spot size, and irradiation time will be discussed. Results of optical distortion and stress-field observations on uncoated and coated samples of KCl, NaCl, and ZnSe are reported.

**10.6 micrometer CW laser damage studies of metal substrate mirrors,** T. T. Saito, G. B. Charlton, and J. S. Loomis, *SP414*, pp. 103-112 (Dec. 1974).

**Key words:** CW laser damage; diamond turned optics; dielectric enhanced metal mirrors; laser beam characterization; metal mirrors.

The CW damage properties of metal substrate mirrors were studied by focusing a 1 KW CW CO<sub>2</sub> laser onto the mirrors. Mirrors studies included polished and diamond machined bare metals, noble metal evaporated coatings, electroplated and then machined metals, and dielectric coated. Experimentally determined damage thresholds and damage statistics are discussed. Extensive efforts to characterize beam area of focused kilowatt beam is included. Evidence of a self-cleaning of mirrors by slowly raising laser power is described. Dust on mirrors reduces the damage threshold below 100 W/cm<sup>2</sup>.

**High absorption damage in infrared filters,** W. S. Otaguro, *SP414*, pp. 113-118 (Dec. 1974).

**Key words:** high absorption damage; infrared filters; laser-induced damage.

The damage morphology, degradation of filter transmission, and thresholds for damage of infrared filters subjected to a hostile environment where the radiation incident on the

filters includes high power densities in a wavelength region of high absorption have been examined. Infrared filters cooled to 10 kelvin exhibited damage thresholds at 5 megawatts per square centimeter when illuminated with a Q-switched ruby laser. A thermodynamic model based on intrinsic absorption of the material composing the multilayer coatings is compared to the measured damage thresholds.

**Q-switched laser induced surface damage at 1.06 microns,** N. L. Boling, J. A. Ringlien, and G. Dubé, *SP414*, pp. 119-130 (Dec. 1974).

**Key words:** electron avalanche; laser; laser induced damage.

Our studies of the effect of "superpolishing" on the surface damage threshold indicate that such polishing does not increase the practical threshold on ED-2 glass. Impurities introduced in the polishing process often outweigh any advantages that might be gained in longer polishing to reduce geometrical defects.

On commercially available, "conventionally" polished laser glass, the surface threshold is about 150 J/cm<sup>2</sup> (5 GW/cm<sup>2</sup>). This is at least an order of magnitude below the intrinsic bulk threshold. Some problems encountered in using small beams to measure the surface-to-bulk ratio are discussed.

The effect of treating ED-2 laser glass with boiling nitric acid is also briefly described. This treatment can permanently raise the threshold by as much as a factor of three, while leaving the surface in good optical condition. The efficacy of the treatment is highly dependent on the polishing history of the sample.

**Damage in nonlinear optical materials at 1.06  $\mu\text{m}$ : Surface treatment of LiNbO<sub>3</sub> in Ar-O<sub>2</sub> plasmas and high pressure O<sub>2</sub> environment,** J. C. Potosky and C. R. Giuliano, *SP414*, pp. 131-134 (Dec. 1974).

**Key words:** LiNbO<sub>3</sub>; 1.06  $\mu\text{m}$ ; oxygen deficiency; surface damage; surface treatment.

Surface damage in LiNbO<sub>3</sub> has been studied at 1.06  $\mu\text{m}$  as a function of different surface treatments. While the use of ion beam polishing on LiNbO<sub>3</sub> has resulted in general degradation of surface finish and decrease in damage resistance, a different type of plasma treatment shows a distinct improvement. This method of surface treatment is one in which the sample is bombarded in a low energy rf-excited plasma of argon and oxygen. Under this type of plasma treatment, the damage resistance is substantially improved (~50%) over that of the conventionally polished surface of the same sample. To avoid complications of possible cumulative effects in the damage experiments, each point on the surface is laser irradiated only once at any given power. The results are presented in terms of the fraction of surface which resists damage for a given incident energy.

That this improvement in threshold involves a surface-oxygen effect is supported by another series of preliminary measurements in which damage tests were performed on LiNbO<sub>3</sub> at 10 to 15 atm O<sub>2</sub> pressure. Under these conditions, the surface was usually seen to completely resist damage at levels of irradiation at least twice that at which damage occurred at ambient conditions or in a high pressure nitrogen environment.

**Surface characteristics related to laser damage of lithium niobate and potassium chloride surfaces,** J. O. Porteus, E. A. Teppo, and J. H. Dancy, *SP414*, pp. 135-140 (Dec. 1974).

**Key words:** Auger electron spectroscopy; ion beam profiling; laser-induced damage; lithium niobate; potassium



chloride; surface acoustic waves; surface characterization; transmission electron microscopy.

Laser damage of transparent materials is promoted by irregularities in topography and surface composition. Changes in these characteristics following laser irradiation can provide insight on damage mechanisms. Transmission electron micrographs of replicated  $\text{LiNbO}_3$  surfaces which have been chemically etched show submicroscopic pitting similar to that previously observed following laser irradiation. Experiments designed to explore a possible role of surface-acoustic waves in the laser-induced pitting are in progress. Auger analysis of coated  $\text{LiNbO}_3$  surfaces following visible laser damage have helped to identify redistributed surface material. Profiling of the coating shows evidence of C contamination layers near the substrate surface. Preliminary Auger spectra of KCl surfaces show promise for similar studies on this material.

**Characterization of infrared laser window materials at the National Bureau of Standards**, A. Feldman, I. Malitson, D. Horowitz, R. M. Waxler, and M. Dodge, *SP414*, pp. 141-148 (Dec. 1974).

Key words:  $\text{As}_2\text{S}_3$ ; chalcogenide glass; coefficient of thermal expansion; elastic constants; infrared laser window materials; KCl; photoelasticity; polycrystalline ZnSe; refractive index; stress-optical constants; thermal coefficient of refractive index.

A program has been established for measuring refractive index,  $n$ , stress-optical constants,  $q_{ij}$ , change of index with temperature,  $dn/dT$ , thermal expansion coefficient,  $\alpha$ , and elastic compliances,  $s_{ij}$ , of infrared laser window materials. These parameters are necessary for determining the optical distortion that occurs in windows due to heating by the absorption of high power laser radiation.  $n$  and  $dn/dT$  are measured over a spectral range 0.2 to 50  $\mu\text{m}$  by the method of minimum deviation on precision spectrometers. Twyman-Green and Fizeau interferometers, which operate at 0.6328  $\mu\text{m}$ , 1.15  $\mu\text{m}$ , and 10.6  $\mu\text{m}$ , are used for measuring  $q_{ij}$ ,  $\alpha$ ,  $dn/dT$  and  $s_{ij}$ . Materials currently under study are polycrystalline ZnSe,  $\text{As}_2\text{S}_3$  glass, chalcogenide glass (Ge 33%, As 12%, Se 55%), and KCl. Results are given for  $n$  and  $dn/dT$  in KCl, and  $q_{ij}$  and  $s_{12}$  in ZnSe,  $\text{As}_2\text{S}_3$  glass, and chalcogenide glass.

**Testing the surface quality of laser materials**, M. J. Soileau and H. E. Bennett, *SP414*, pp. 149-156 (Dec. 1974).

Key words: laser damage; light scattering; optical surface quality; scratch detection.

Research presented at the 1973 Laser Damage Symposium clearly showed that surface microcracks and pits influence laser damage thresholds for optical materials. In addition, backscatter from laser amplifiers can result in damage to oscillator optics in high power oscillator-amplifier systems. The scratch and dig specifications presently used to specify optical surface quality are inadequate since (1) they address only the problem of surface irregularities larger than 2  $\mu\text{m}$  (Bloembergen has shown theoretically that pits or scratches as small as 100  $\text{\AA}$  can significantly reduce damage thresholds), and (2) compliance is determined in a subjective manner. The relationship between surface quality and light scattering from transparent optical components is discussed, and an instrument for measuring bulk scattering and surface quality described. Quantitative measurements on a set of standard scratches and digs are presented, as well as measurements of surface imperfections and bulk scattering in optical materials used in infrared laser systems.

**Statistical characterization of mirror and window surfaces**, J. M. Bennett, *SP414*, pp. 157-162 (Dec. 1974).

Key words: autocovariance laser damage statistical characterization of surface; FECO interferometry; scattered light; surface roughness.

In order to evaluate the contribution of surface structure to laser damage and to calculate the magnitude and angular distribution of scattered light from laser mirrors, windows, and other optical surfaces, the autocovariance function, rms roughness and height distribution functions are required. These and other statistical parameters for optical surfaces can now be determined with a FECO Scanning Interferometer, which consists of a FECO interferometer, slow scan television camera, signal averager, minicomputer, and telescope. Wavelengths are measured at 512 equally spaced points along the length of an interference fringe (which contains irregularities on the optical surface under investigation). The fringe length corresponds to a total length of 1 mm on the interferometer surface. The statistics for the surface are obtained from the wavelength data. The system has the advantages that it does not depend on visual estimates of fringe width to yield a value of the rms roughness, and additional statistical information such as the autocovariance function and height distribution function can be obtained which cannot be determined visually.

**Roughness measurement by light scattering**, J. C. Stover, *SP414*, pp. 163-168 (Dec. 1974).

Key words: light scattering; sinusoidal grating diffraction; spatial spectral density function; surface roughness.

Theoretical and experimental descriptions of how light scatters from sinusoidal gratings lead to the relationship between light scattered from an arbitrary surface and the spatial power spectral density function of that surface. With an appropriate measurement system, this relationship lends itself to studying the correlation between damage threshold and surface topography for surfaces in the 10 to 500  $\text{\AA}$  (rms) range. Experimental results are given for various types of sinusoidal gratings (variation in magnitude, frequency and material) and several arbitrary surfaces. Measurements of samples submitted by outside laboratories have been taken.

**Laser-damage-mechanism identification by the measurement of survival times**, D. Milam, R. A. Bradbury, R. H. Picard, and M. Bass, *SP414*, pp. 169-178 (Dec. 1974).

Key words: absorbing inclusions; absorption; bulk dielectrics; dielectric films; dielectric surfaces; electric field enhancement; electron-avalanche breakdown; laser-damage statistics.

The mechanism responsible for laser-induced damage can be determined from the statistical fluctuation in the times required to produce damage at many sites which were sequentially irradiated by equally-intense, square-waveform pulses. Damage mechanisms are readily separated into three general categories: (1) Homogeneous absorption, (2) damage due to material defects or inclusions, and (3) intrinsic damage due to electron-avalanche breakdown or other fast intrinsic mechanisms.

**The dynamics of transmitted, reflected, and scattered laser pulses above and below damage threshold: The search for precatastrophic damage**, C. R. Giuliano, *SP414*, pp. 179-189 (Dec. 1974).

Key words: back-scattering; precatastrophic damage; pulse dynamics; reflection; ruby laser; surface damage; temporal pulse monitoring; transmission; 0.694  $\mu\text{m}$ .



This paper deals with a detailed study of the temporal shapes on a nanosecond time scale of laser pulses that are transmitted, back reflected, Brewster reflected, and backscattered at small angles for different powers below and above surface damage threshold. The sharp cutoff in transmitted light above damage threshold is accompanied by a corresponding cutoff in reflected light while the small angle backscattered light shows a sharp increase at the same time. The shapes of the transmitted and reflected pulses are essentially the same over a wide range of powers from below damage threshold to  $\sim 10\times$  above threshold. The small angle backscattered intensity is the most sensitive measure of the very onset of surface damage in that while the transmitted pulse shows essentially no change in shape for powers slightly above damage threshold, the backscattered component shows a marked increase in intensity. These results, along with the intensity dependence of Brewster reflected pulses, are discussed in terms of possible precatastrophic damage effects.

**Rutherford backscattering diagnostics of laser-irradiated GaAs,** R. R. Hart, C. R. Giuliano, and H. L. Dunlap, *SP414*, pp. 190-192 (Dec. 1974).

Key words: ion channeling; laser-damaged GaAs; Rutherford backscattering; scattering centers.

The Rutherford backscattering of 280 keV  $\text{He}^{++}$  has been used to study the amount and depth distribution of lattice disorder introduced in GaAs by intense laser irradiation. The lattice remains largely intact after irradiation at a laser power level of three times the damage threshold (optical) except within a 175 Å surface layer. In this surface layer the number of scattering centers increases to about 2.5 times the number of Ga and As atoms present in the surface oxide on undamaged GaAs.

**Surface defects on crystals of  $\text{TiO}_2$  and  $\text{YVO}_4$  studied by laser-induced damage effects,** K. M. Leung and L. G. DeShazer, *SP414*, pp. 193-199 (Dec. 1974).

Key words: damage morphology; polishing compounds; spot-size dependence; surface defects; rutile crystal damage; yttrium orthovanadate crystal damage.

The nature of surface defects on single crystals of rutile ( $\text{TiO}_2$ ) and yttrium orthovanadate ( $\text{YVO}_4$ ) was investigated by laser-induced damage effects using a TEM<sub>00</sub> Q-switched ruby laser. It was demonstrated that damage to these crystal surfaces can be distinguished as defect damage and intrinsic damage, where the damage thresholds decreased with increasing focal spot-size of the laser beam. The dependence on the directions of crystallographic axes and electric field was studied. The morphology of the surface damage sites was examined by the scanning electron microscope revealing that polishing imperfections were the cause of damage on  $\text{TiO}_2$  surface and inclusions were the cause of damage in the case of  $\text{YVO}_4$ .

**Pulsed  $\text{CO}_2$  laser window damage processes,** R. A. Shatas, J. D. Stettler, L. M. Narducci, S. S. Mitra, and H. C. Meyer, *SP414*, pp. 200-206 (Dec. 1974).

Key words: damage threshold of GaAs; extended Shockley avalanche; pulsed laser damage; semiconductor infrared windows; solid state plasma; two-stream instability threshold.

We examine the applicability of the extended avalanche breakdown process to describe the semiconductor window

surface damage by pulsed high pressure  $\text{CO}_2$  lasers. In the extension to optical frequencies of Shockley's avalanche theory construed originally for a dc electric field, a hard momentum-reversing collision of the free carrier is required to occur at the instant of optical field reversal. In contrast to alkali halides, the mobility is very high in semiconductors, and the probability of a momentum-reversing collision is too small to account for experimental observations of damage thresholds. Alternate models of damage processes are discussed. They are based on quantum mechanical photon assisted tunneling probability calculations between the bound and the quasi-free states and resonant collective excitations of carriers in the quasi-free state. Theoretical predictions for maximum pulsed  $\text{CO}_2$  laser fluxes are made for some typical semiconducting window materials.

**Frequency dependence of the nonlinear optical susceptibility of five glasses,** R. Hellwarth, J. Cherlow, and T-T. Yang, *SP414*, pp. 207-213 (Dec. 1974).

Key words: ac Kerr effect; glasses; nonlinear optical effects; nonlinear optical susceptibility; self-focusing; three-wave mixing.

The frequency dependence of the nonlinear susceptibility throughout the optical region of fused quartz, ED-4, LSO, SF-7, and LaSF-7 glasses is derived in a novel and useful form from Raman-scattering and intensity-induced polarization change measurements.

**The refractive index dependence of pulsed laser induced damage,** J. R. Bettis, A. H. Guenther, and A. J. Glass, *SP414*, pp. 214-218 (Dec. 1974).

Key words: bulk; electro-absorption; electron avalanche; laser damage; local field corrections; refractive index; surfaces; thin films.

The dependence of the laser induced damage threshold on refractive index has been investigated. A simple theoretical expression, based upon several factors such as the local electric field and avalanche mechanisms, has been derived. Comparison is made with several series of previously published results to verify the proposed dependence. Strikingly good agreement is obtained between theory and experiment for materials with refractive indices ranging from 1.38 to 2.36. The available experimental data used for comparison were obtained (1) on the surface of uncoated dielectrics, (2) in the bulk of alkali halides, (3) with  $\lambda/4$  dielectric coatings and (4) with vapor phase mixture thin films. Extrapolations of these results to conditions for air at STP give remarkable agreement with reported values of pulsed laser induced air breakdown.

**Extrinsic absorption in laser window materials,** C. J. Duthler and M. Sparks, *SP414*, pp. 219-226 (Dec. 1974).

Key words: absorbing inclusions; alkali halides; impurity absorption; laser damage.

Two types of extrinsic absorption are discussed. First, our calculations on absorbing inclusions, presented at the 1973 symposium, have been extended to explain the cone-shaped surface pits observed by Boling. For a spherical inclusion of radius  $a$  located a distance  $d$  below the surface, the cone half-angle is  $\theta_m = \cos^{-1}(a/d)$ . The second type of absorption is that due to polyatomic molecular-ion impurities in alkali halides. A literature survey indicates that concentrations of less than 0.1 ppm of  $\text{NO}_2^-$ ,  $\text{HCO}_3^-$ ,  $\text{SO}_4^{2-}$ , or  $\text{CrO}_4^{2-}$  will result in a bulk absorption coefficient  $\beta(10.6 \mu\text{m}) > 10^{-4} \text{ cm}^{-1}$ .

### 3.8. APPLIED MATHEMATICS SERIES

Mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and

technical work.

No publications issued in this series during this period.

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Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NBS. Program under the authority of National Standard Data Act (Public Law 90-396).

**NSRDS-NBS47. Tables of collision integrals and second virial coefficients for the (m,6,8) intermolecular potential function**, M. Klein, H. J. M. Hanley, F. J. Smith, and P. Holland, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 47, 157 pages (June 1974) SD Catalog No. C13.48:47.

Key words: collision integrals; diffusion; potential; thermal conductivity; thermal diffusion; transport properties; viscosity.

Tables of collision integrals and second virial coefficients are presented for the (m,6,8) potential function. Ten values of the repulsive exponent  $m$  are included which range in unit steps from  $m=9$  through  $m=18$ . Approximately 6 values of the parameter,  $\gamma$ , associated with the inverse eighth power term, are included for each value of  $m$ . These tables are equivalent, therefore, to tables for 60 three-parameter (m,6) potential functions. Comparisons of our results for  $m=12$  and  $\gamma=0$  (corresponding to the (12,6) function) have been made with other calculations. Based on these comparisons, the accuracy of the present calculation appears to be at least two or three parts in 10,000 depending on the temperature. A table is included which contains the Boyle temperature, the Boyle volume, and the ratio of the intermolecular separation at the potential minimum to the separation at the zero of the potential.

**NSRDS-NBS48. Radiation chemistry of ethanol: A review of data on yields, reaction rate parameters, and spectral properties of transients**, G. R. Freeman, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 48, 43 pages (Feb. 1974) SD Catalog No. C13.48:48.

Key words: chemical kinetics; data compilation; ethanol; G; radiation chemistry; rates; review; spectra.

The yields (G) for products and intermediates formed by irradiation of ethanol, in the solid, liquid and gaseous state, have been compiled and reviewed. Rates of reactions of transient ions and radicals and spectroscopic parameters, including optical and esr spectra, are also included.

**NSRDS-NBS49. Transition metal oxides. Crystal chemistry, phase transition and related aspects**, C. N. R. Rao and G. V. Subba Rao, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 49, 138 pages (June 1974) SD Catalog No. C13.48:49.

Key words: critical data, transition metal oxides; crystal structure transformations; electronic properties; magnetic properties; phase equilibria; phase transitions.

A survey is made of the data describing the thermodynamics of phase equilibria, crystal chemistry and phase transformations of binary oxides of 3d, 4d, and 5d transition metals. Changes in electrical, magnetic, and other properties which accompany phase transitions are discussed. Nearly complete coverage of the literature is provided up to 1973.

**NSRDS-NBS52. Electronic absorption and internal and external vibrational data of atomic and molecular ions doped in alkali halide crystals**, S. C. Jain, A. V. R. Warriar, and S. K. Agarwal, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 52, 59 pages (July 1974) SD Catalog No. C13.48:52.

Key words: atomic ions; doped alkali halide crystals; external vibrational modes; internal vibrational modes; molecular ions.

Spectral data for more than 70 atomic and molecular ions doped in alkali halide crystals are tabulated. The tables include electronic absorption data, listings of internal vibrational frequencies of doped complex ions, and tabulations of the frequencies of external modes. The data that appear in the tables were selected on the basis of the consistency among different authors, the types of instruments, and the temperature of measurement. In addition to the data, the tables include the spectroscopic assignments given by the authors in the references cited.



### 3.10. BUILDING SCIENCE SERIES

Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

**BSS48. Design, siting, and construction of low-cost housing and community buildings to better withstand earthquakes and windstorms.** W. F. Reps and E. Simiu, Eds., Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 48, 152 pages (Jan. 1974) SD Catalog No. C13.29/2:48.

Key words: buildings; construction; design; developing countries; earthquakes; low-cost housing; natural disasters; structures; windstorms.

The extensive loss of life and property caused in developing countries by earthquakes and windstorms (hurricanes, typhoons and tropical cyclones) may be reduced to a considerable degree by the adoption and implementation of improved design, siting and construction procedures practicable within the context of the cultural and socioeconomic constraints prevailing in these countries.

The report provides technical information regarding characteristics of materials and building systems, and discusses the structural performance of buildings subjected to the action of earthquakes and wind forces with specific reference to structures typical of developing countries. Potential ways are described in which structures can be made more resistant to such action. Siting considerations are discussed from a geological, seismic and climatological viewpoint, and recommendations relating to siting problems are made. Techniques of housing construction, both traditional and industrialized, are described and improvements resulting in better earthquake or windstorm resistance are suggested. Building codes, their improvement and their enforcement are also discussed.

The report discusses cultural and socio-economic constraints influencing the adoption of improved practices, describes various feasible technical improvements of construction materials, composite systems and building systems, identifies mechanisms for stimulating technical improvements and discusses the role of institutions in this regard. Throughout the report, specific references are made to Peru, the Philippines and Turkey, countries which suffer from frequent devastation from natural disasters such as earthquakes and typhoons and which were selected as case studies for the purpose of this report.

**BSS49. Laboratory studies of the hydraulic performance of one-story and split-level residential plumbing systems with reduced-size vents.** R. S. Wyly, G. C. Sherlin, and R. W. Beausoliel, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 49, 53 pages (Mar. 1974) SD Catalog No. C13.29/2:49.

Key words: hydraulic criteria for plumbing; hydraulic test loads; plumbing-vent sizing; reduced-size vents; sanitary DWV systems; secondary ventilation; testing plumbing systems; vents for plumbing.

A laboratory study on one-story and split-level experimental drainage systems where the vents in some cases were varied from one to six pipe-sizes smaller than those presently specified by codes showed satisfactory hydraulic and pneumatic performance under various loading conditions. The research was originally sponsored by the National Association of Home Builders and the National Bureau of Standards and more recently by

a program of the Department of Defense through the Tri-Services Investigational Committee on Building Materials. This paper presents criteria recommended for the design and evaluation of systems using reduced-sized vents and a sizing table for one- and two-story systems. The laboratory work also contributed to the development of analytical and test procedures needed for evaluating the application of reduced-size venting to a broad range of innovative drain-waste-vent designs for buildings of any height.

This work indicates that, in some circumstances, reduced-size venting might be a good alternative to other types of drainage systems for multistory buildings which use either conventional or innovative venting concepts. Because this study involved only a limited number of drainage system designs, it is recommended that ongoing field and laboratory studies be explored if code changes are contemplated to permit the use of smaller vents.

**BSS50. Weather resistance of porcelain enamels—15-year inspection of the 1956 exposure test.** M. A. Baker, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 50, 15 pages (July 1974) SD Catalog No. C13.29/2:50.

Key words: acid resistance; color; gloss; pH; porcelain enamel; relative humidity; weather resistance.

In 1956, an exposure test of porcelain enamels at 4 urban and 2 ocean shore sites in the continental United States was initiated by the National Bureau of Standards and the Porcelain Enamel Institute. After 15 years, all exposed specimens were returned to the Bureau and the changes in gloss and color determined. The gloss changes were found to be significantly different at all exposure sites except Pittsburgh, Los Angeles and Dallas. The most severe changes occurred at the Kure Beach, N.C., site nearest the ocean, while the least changes occurred at Pittsburgh, Los Angeles and Dallas. The differences in behavior of the specimens correlated with both the average relative humidity and the pH of the suspended particulate matter at the different sites.

A correlation appeared to exist between the acid resistance of the enamels and changes in gloss and color. The regular, glossy, acid-resistant enamels on steel showed the best weather resistance of the various types tested.

Comparison with enamel specimens exposed for 15 years in an earlier test showed that porcelain enamels produced in the early 1950's were equally resistant to changes in gloss and color as those produced in the late 1930's.

**BSS51. Structural evaluation of steel faced sandwich panels.** J. H. Pielert, T. W. Reichard, and L. W. Masters, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 51, 43 pages (Apr. 1974) SD Catalog No. C13.29/2:51.

Key words: accelerated aging; adhesive bond; ductility; flexural shear; housing systems; local buckling; material variability; moisture conditioning; Operation BREAKTHROUGH; paper honeycomb; structural sandwich; sustained load.

A series of structural evaluation tests performed on components and materials intended for use in one of the Operation BREAKTHROUGH housing systems is described. Four samples of steel faced, paper honeycomb, sandwich panel material and four full size prototype roof panels were evaluated.

The samples of sandwich panel material were used to evaluate the variability of panel material properties and the effect of aging



on tensile and shear strength. The roof panels were used to determine the behavior in service considering the effects of adverse environmental conditions on ultimate strength and mode of failure. In addition, the performance of one panel under sustained loading was evaluated.

**BSS52. The effect of impact loadings on the performance of wood joist subflooring systems**, H. S. Lew, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 52, 35 pages (May 1974) SD Catalog No. C13.29/2/52.

Key words: concentrated load; deflection; floor; hardboard; housing; impact energy; Operation BREAKTHROUGH; plywood; subfloors; underlayment; wood; wood joists.

This report presents the results of an experimental study of wood-joist subflooring systems subjected to impact load. Six different types of subflooring systems were tested following the test method described in the ASTM Standard Methods (ASTM Designation E-72). The magnitude of impact load was varied by dropping a 60-lb bag from different heights.

A concentrated static load of 400 lb was applied to the subfloor after it was exposed to impact load. It is suggested that the deflection under this concentrated load be used as a measure of the impact resistance of the subfloor. Supersedes NBSIR 73-187 (PB 221-188).

**BSS53. Study of the local resistance of conventional plywood subflooring to concentrated load**, F. Y. Yokel, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 53, 43 pages (May 1974) SD Catalog No. C13.29/2/53.

Key words: evaluation criteria; floors; hardboard; load capacity; performance criteria; plywood subflooring; subflooring; underlayment; wood-frame construction.

Representative specimens, simulating the performance of five conventional plywood floor systems, were tested under concentrated load in order to compare their performance with that stipulated by performance criteria developed on the basis of anticipated occupancy loads.

In 24 out of 26 tests the performance of the specimens exceeded that required by the criteria. Data on failure loads, load-deflection characteristics and failure modes are presented and discussed. Supersedes NBSIR 73-116 (PB 220-432/9).

**BSS54. Health and medical facilities design**. Proceedings of the First Federal Agency Workshop, held at the National Bureau of Standards Gaithersburg, Md., December 5, 1972, R. J. Kapsch, Ed., Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 54, 87 pages (July 1974) SD Catalog No. C13.29/2/54.

Key words: architecture; design; hospital design; medical facilities; medical facility research.

The Federal Agencies have a large involvement in this area of Medical Facility Design; both in directly operated Federal facilities and indirectly through grant, loan and funding programs. Because of the impact of technology and because of the very large cost for new medical facilities in the last few years, there has been the rise of a field best described as medical facility research. These papers, presented at a National Bureau of Standards Federal Agency Workshop, describe the latest medical facility research efforts by the Federal Agencies including, the Department of Defense, Department of Health, Education, and Welfare, the Veterans' Administration and the National Bureau of Standards. *These proceedings include the following papers (indented):*

**The new generation hospital**, S. I. Gerber, BSS54, 1-12 (July 1974).

Key words: architecture; design; hospital design; medical facilities; military construction; new generation military hospital; system design.

The Department of Defense has some 240 major hospitals and 460 dispensaries serving over 10 million people and employing about one quarter of a million medical and allied personnel. In 1968, a new project was initiated; A New Generation of Military Hospitals. The objectives of this project were to provide a more efficient health care delivery system through the extensive use of technology. The project consisted of two phases; Phase I was the systems analysis study of military and civilian hospitals and Phase II was the design and construction of a test bed military hospital. A number of recommendations resulted from Phase I, including use of a completely computerized hospital, convenience food system, light care nursing, outpatient surgery and others. Travis Air Force Base in California was selected as the site for implementation of Phase II. The organization and the planning of this project are discussed. The beneficial occupancy of the Phase II, Travis Hospital is scheduled for 1977.

**Rationale for change—The Hill-Burton Program**, J. W. Reese, BSS54, pp. 13-24 (July 1974).

Key words: architecture; building regulations; construction standards; design; Hill-Burton; hospital design; medical facilities.

The Hill-Burton Program was established in 1946 for the financing of needed health facilities in the United States. An important function of the Hill-Burton Program is the continual updating of minimum construction requirements with which Hill-Burton projects must comply. Many States, architects, and engineers use these requirements for all health facility construction. Some of the newly proposed changes described include modification of Fire Safety requirements to make them compatible with other government agencies; improved parking facilities; increased emphasis on making health facilities accessible to the physically handicapped; a new section for intensive and coronary care units, and a new section dealing with natural disasters. Government building regulations will continue to change, probably in the direction of making the environment more livable and in the increased concern for conserving human resources.

**Space planning and equipment requirements—application of advanced technologies to hospital design in the Veterans' Administration**, H. J. Fogarty, BSS54, pp. 25-26 (July 1974).

Key words: criteria; hospital planning; medical facilities; planning; Veterans' Administration.

Prior to 1958, the Veterans' Administration (VA) used a 500 bed prototype as the basis of all design and construction. This proved undesirable since almost all new VA hospitals were to be teaching facilities with widely varying requirements not well suited to any single prototype. At the end of the 1950's the Bureau of the Budget issued the Federal Space Planning Criteria. The VA expanded and refined this criteria and has been successfully applying it for over ten years.

**Use of the computer in planning hospitals—application of advanced technologies to hospital design in the Veterans' Administration**, B. D. Keane, BSS54, pp. 27-30 (July 1974).

Key words: computer-aided planning; design; electronic data processing; hospital planning; medical facilities; planning; Veterans' Administration.



In 1965, the Veterans' Administration (VA) began developing the facilities Planning and Construction Requirements System to aid the VA in planning new facilities. This system is presently in use today. This computerized system utilizes files containing medical statistics, staffing, criteria and other information necessary for hospital planning. This system produces a master plan. This master plan provides a listing of medical functions, projected staffing, space requirements and other information. After review and approval of this master plan, it is used by architects and engineers for the design of VA hospitals. Future work on this system will include provisions for equipment, addition of special environmental factors and extension of the system to field station management.

**Veterans' Administration Hospital Building System—application of advanced technologies to hospital design in the Veterans' Administration, J. C. Cook, *BSS54*, pp. 31-44 (July 1974).**

Key words: architecture; building systems; design; hospital design; medical facilities; modular design; performance; Veterans' Administration.

The Veterans' Administration (VA) Hospital Building System was begun to provide new VA Hospitals with improved cost control, improved performance, increased adaptability, a reduction in the time to go from planning to beneficial occupancy and to provide a system that could be continuously updated. The Building System is composed of three parts; the data base, the planning modules and the building subsystems. The data base contains the "user needs" necessary to determine functional and performance requirements for new VA Hospitals. The planning modules are areas of space large enough to accommodate a wide variety of hospital activities. Four types of planning modules are used: a structural bay with a constant width of 22.5 feet (6.86 meters); a service module of from 5000 square feet (464.5 square meters) to 15,000 square feet (1393.5 square meters); a space module, which is a sub-unit of the service module and a fire section not to exceed 20,000 square feet (1858.0 square meters). The building subsystems are the components of the VA Hospital Building System. Six subsystems have been developed in detail; structure; partitions; ceiling; heating-ventilating-cooling; plumbing distribution; and electrical distribution. Advantages of the application of the VA Hospital Building System include better response to the medical program, more accurate estimate and control of costs, improved performance, better functioning of the building and increased adaptability.

**Introduction—current issues in health care facility delivery, D. D. Boyle, *BSS54*, pp. 45-48 (July 1974).**

Key words: architecture; construction; design; hospital design; management; medical facilities; performance specifications.

Some of the issues of concern to Health Care Facility Delivery are better planning, better prediction of facility needs, improved sensitivity to the need for responsive facilities, containment of parochial attitudes, restatement of the emphasis in planning and design and improvement of the management process. Failures in this area include lack of consideration of life cycle cost, non-utilization of available management and procedural skills and the numerous Federal, regional, State and local building and life safety codes that hamper technological advance. In a recent report to Congress, the General Accounting Office (GAO) identified these items and others and provided detailed recommendations. The Facilities Engineering and Construction Agency (FECA) presently has three projects deal-

ing with these issues and problems. These projects include the investigation of the design process, the construction of three office buildings to performance specifications and using new management concepts and the third is the construction of five Indian Health Service hospitals using a sophisticated management plan.

**Application—current issues in health care facility design, J. D. Russo, *BSS54*, pp. 49-62 (July 1974).**

Key words: architecture; building systems; construction management; design; hospital design; medical facilities; performance; planning; programming.

The Facilities Engineering and Construction Agency (FECA) is presently accomplishing a project for the delivery of five health facilities. Unlike conventional projects, FECA commissioned an Executive Architect/Engineer (A/E) to review the programs of requirements, develop a functional definitive design kit upon which schematics would be based and to oversee the work of five regional A/E's who would be responsible for final design. Other unique aspects of this project include the use of a flexible management system, the use of a functional definitive design kit, the requirement for a guaranteed maximum price early in the design process from the construction manager and other innovations. Benefits include better quality Health Facilities delivered in shorter time and at a lower cost than through traditional means and the basis for continuous improvements of future health care facilities.

**An evaluation methodology for hospital nursing units, R. Wehrli, *BSS54*, pp. 63-76 (July 1974).**

Key words: architecture; design; evaluation; hospitals; medical facilities; nursing units.

Hospital planners and designers are facing the twin trends of greater construction costs and greater demand to access to the health care delivery systems. Because of these twin trends, these planners and designers must become increasingly aware of the various requirements involved in nursing units. One method of achieving this is through evaluation. The evaluation methodology that was developed by the Architectural Research Section relies on the research aids of architectural psychology, building systems and the performance approach. In this methodology, requirements are systematically identified and schematic drawings of nursing units are weighted and rated based on these requirements. When allied with costs, this methodology permits a comparison of various schemes on a performance-cost basis. It also aids the designer in improving his design of nursing units.

**BSS55. Preliminary performance criteria for bituminous membrane roofing, R. G. Mathey and W. C. Cullen, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 55, 16 pages (Nov. 1974) SD Catalog No. C13.29/2:55.**

Key words: bituminous roof membranes; performance attributes; performance criteria; physical and engineering properties; test methods.

This report is the first in a series of publications on performance criteria for built-up roof membranes. The development of a performance approach to bituminous built-up roof membranes is described and preliminary performance criteria are recommended. A number of test methods have been developed in order to obtain data to evaluate roofing membranes against the recommended criteria. Twenty attributes that effect the performance of roof membranes under service conditions are identified and laboratory tests are described for measuring the engineering properties of the membrane that pertain to many of



these attributes. A level of performance is recommended for nine of the identified performance attributes.

**BSS56. Development of improved design criteria for low-rise buildings in developing countries to better resist the effects of extreme winds**, Proceedings of a Workshop held at the Dr. Paulino J. Garcia Memorial Hall, National Science Development Board, Manila, Philippines, Nov. 14-17, 1973, N. J. Raufaste, Jr., and R. D. Marshall, Eds., Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 56, 171 pages (Oct. 1974) SD Catalog No. 13.29/2:56.

Key words: codes and standards; information transfer; low-rise buildings; pressure transducers; socio-economic; structural design; technology implementation; wind effects; wind loads.

An International Workshop held in Manila, Philippines, on November 14-17, 1973, addressed the state-of-the-art in mitigating building damages from winds. The workshop was jointly sponsored by the United States Agency for International Development (USAID), the Philippine Advisory Committee (formed in conjunction with this research project), and the U.S. National Bureau of Standards (NBS). This report presents the proceedings derived from the workshop. The proceedings present recommendations, the workshop program, five reports, and nine technical articles. The technical articles addressed four primary topics which were used to guide subsequent workshop discussions. The topics addressed were: wind and aerodynamics, structural related technology, socio-economic and architectural considerations, and codes and standards.

The results of the workshop will serve a twofold purpose. The first suggests improved building practices for developing countries. This was accomplished through the development of recommendations designed to upgrade to a minimum acceptable level design criteria for low-rise buildings. The second involves integrating appropriate workshop information into the overall three-year AID sponsored research project to develop improved design criteria for low-rise buildings in developing countries to better resist the effects of extreme winds. *These proceedings include the following papers (indented):*

**Climatology and wind related problems in the Philippines**, R. L. Kintanar, *BSS56*, pp. 28-62 (Oct. 1974).

**Aerodynamics of structures and wind tunnel modeling**, R. D. Marshall, *BSS56*, pp. 63-76 (Oct. 1974).

**Some problems in the analysis of lateral wind force resisting systems**, J. Ma. de Castro, *BSS56*, pp. 78-90 (Oct. 1974).

**Socio-economic and architectural considerations in housing**, G. V. Manahan and J. M. Ramos, *BSS56*, pp. 91-98 (Oct. 1974).

**Lessons learned from post wind disaster investigation**, E. O. Pfrang, *BSS56*, pp. 99-101 (Oct. 1974).

**Low-rise low-cost housing and extreme wind related problems in Bangladesh**, J. R. Choudhury, *BSS56*, pp. 102-120 (Oct. 1974).

**Low-cost housing and extreme-wind-related problems in Jamaica**, A. D. Adams, *BSS56*, pp. 123-139 (Oct. 1974).

**Wind pressure provisions of the National Building Code Republic of the Philippines**, A. R. Flores, *BSS56*, pp. 140-152 (Oct. 1974).

**Standardization in the Philippines today**, A. R. Flores, *BSS56*, pp. 153-155 (Oct. 1974).

**Wind research in the United Kingdom**, K. J. Eaton, *BSS56*, pp. 156-159 (Oct. 1974).

**BSS58. State-of-the-art of structural test methods for walls, floors, roofs and complete buildings**, C. W. C. Yancey and L. E. Cattaneo, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 58, 136 pages (Nov. 1974) SD Catalog No. C13.29/2:58.

Key words: building construction; complete buildings; floors; roofs; standardization; test methods; walls.

As part of a comprehensive research program concerned with the structural testing of building components, conducted for the U.S. Department of Housing and Urban Development (HUD), a search for information was conducted. This search was undertaken in order to document existing information pertaining to structural testing of wall, floor and roof assemblies. Various information sources were consulted to trace the evolution of structural testing of building construction from the 1930's to the present time. This task was a prerequisite to defining the state-of-the-art and to identifying the test areas requiring fundamental research.

Based on information obtained from a review of the literature and from liaison with committees concerned with the development and revision of voluntary standards, it was found that there is a dearth of research information contributing directly to the development of test methods. Most of the research conducted on building components has been carried out either to observe the behavior of a sample of a particular type of construction or to evaluate the performance of a specimen against some performance requirements. However, helpful interferences can be made on the basis of some of the documentation, especially that contained in reports of full-scale tests on housing.

As a result of comparing the test methods used by the National Bureau of Standards in HUD project Operation BREAKTHROUGH with American Society for Testing and Materials (ASTM) Standard methods, several recommendations have been made by the authors for improving present structural test practice.

An up-to-date status report of voluntary test standards activities (in the U.S.) was prepared through verbal and written communication with members of the technical subcommittees of ASTM Committee E-6 on Performance of Building Construction.

**BSS59. The adherence of porcelain enamel to aluminum**, M. A. Baker, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 59, 39 pages (Nov. 1974) SD Catalog No. C13.29/2:59.

Key words: adherence; aluminum; electron microprobe; electron microscope; porcelain enamel; spalling; x-ray diffraction.

Electron microscopy, electron microprobe, and x-ray diffraction techniques were used to determine the mechanisms of adherence of porcelain enamel to aluminum. Adherence appears to depend upon diffusion of aluminum into the enamel and further, the diffusion zone should be relatively free of reaction products for the enamel-metal system to retain good adherence after exposure to chemical solutions or to weathering. Round-robin testing of 6063 aluminum extrusions indicated that this alloy could be enameled if care were exercised in the selection of the enamel and the pretreatment.

**BSS64. Retrofitting existing housing for energy conservation: An economic analysis**, S. R. Petersen, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 64, 76 pages (Dec. 1974) SD Catalog No. C13.29/2/64.

Key words: benefit-cost analysis; building economics; building envelope; economic analysis; economic efficiency; energy conservation; engineering economics; insulation; life-cycle costs; marginal analysis; thermal efficiency.

This study examines the economic aspects of energy conser-



vation techniques suitable for retrofitting into existing housing, including insulation, storm windows and doors, and weather stripping. The objective of this study is to determine that combination of techniques which will maximize net dollar savings in life-cycle operating costs for heating and cooling operations in existing homes, subject to specific climate conditions, fuel costs, and retrofitting costs. Using microeconomic marginal analysis we find that such a combination must be economically balanced (i.e., the ratio of savings to cost must be equal at the margin for

each technique) and that each technique should be utilized up to the point where the present value of the life-cycle savings generated by the last increment will just cover the costs of that last increment. Thermal engineering data is combined with the economic analysis in a computer-assisted model which estimates such optimal combinations for a wide range of climatic conditions and fuel costs. These combinations include levels of application higher than what has been previously recognized as "economical."

### 3.11. FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS

Publications in this series collectively constitute the Federal Information Processing Standards Register. The purpose of the Register is to serve as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations). FIPS PUBS will include approved Federal information processing standards information of general interest, and a complete index of relevant standards publications.

**FIPS PUB 8-4. Standard Metropolitan Statistical Areas**, H. E. McEwen, Standards Coordinator, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 8-4, 20 pages (1974) SD Catalog No. C13.52:8-4.

Key words: computers; data processing; Federal Information Processing Standards Publication; representations and codes; Standard Metropolitan Statistical Areas.

This publication provides standard identifications and codes for representing Standard Metropolitan Statistical Areas for the interchange of machine sensible data among agencies. It supersedes FIPS 8-3, Standard Metropolitan Statistical Areas, dated 1973 August 15. The general concept of a Standard Metropolitan Statistical Area, commonly referred to as "SMSA" is one of an integrated economic and social unit with a recognized large population nucleus. The codes are available on Hollerith punched cards. The following data elements are provided: SMSA Title (Name) and SMSA Code. Supersedes FIPS PUB 8-3.

**FIPS PUB 10-1. Countries, dependencies, and areas of special sovereignty**, H. E. McEwen, Standards Coordinator, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 10-1, 27 pages (1974) SD Catalog No. C13.52:10-1.

Key words: ADP standards; computers; data elements and codes; data processing; Federal Information Processing Standards; geography; information processing standards; information systems; representations and codes; standards; statistical data.

This publication provides a list of geographical-political entities of the world and associated standard codes. These entities include independent states, dependent areas, areas of quasi-independence, noncontiguous territories, possessions without population, areas with special sovereignty associations, areas without sovereignty, political regimes not recognized by the United States, and outlying areas of the United States.

**FIPS PUB 12-2. Federal information processing standards index**, H. E. McEwen, Standards Coordinator, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 12-2, 195 pages (1974) SD Catalog No. C13.52:12-2.

Key words: American National Standards; computers; data elements and codes; data processing systems; Federal Information Processing Standards; management information systems; International Organization for Standardization; standards; U.S. Government.

This publication provides material concerning standardization activities in the area of information processing at the Federal, National, and International levels. Also included are related policy and procedural guideline documents. A list of Federal Government participants involved in the development of

Federal Information Processing Standards is provided. This FIPS PUB is revised and updated annually. Supersedes NBS FIPS PUB 12-1.

**FIPS PUB 28. Standardization of data elements and representations**, H. S. White, Jr., Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 28, 12 pages (1973) SD Catalog No. C13.52:28.

Key words: computers; data elements and representations; data processing systems; Federal Information Processing Standards; management information systems; standards; U.S. Government.

Pursuant to the authority delegated to the Secretary of Commerce by Executive Order 11717 (38 FR 12315, dated May 11, 1973), Subtitle A of Title 15 of the Code of Federal Regulations has been amended to add a new Part 6 which implements the provisions of Section III (f) (2) of the Federal Property and Administrative Services Act of 1949, as amended (79 Stat. 1127). This new Part 6 supersedes and replaces in its entirety the provision of Office of Management and Budget Circular A-86 entitled, "Standardization of data elements and codes in data systems," dated September 30, 1967 which was rescinded by the Director of the Office of Management and Budget on August 29, 1973. Part 6 provides policy and identifies responsibilities of executive branch departments and independent agencies for a government-wide program for the standardization of data elements and representations used in Federal automated data systems. This publication provides a copy of Part 6 and other documents relating to this amendment.

**FIPS PUB 29. Interpretation procedures for Federal Standard COBOL**, R. E. Rountree, Jr., Standards Coordinator, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 29, 4 pages (1974) SD Catalog No. C13.52:29.

Key words: COBOL; compilers; data processing; Federal Information Processing Standard; information interchange; information processing; programming language; software.

This FIPS PUB defines the procedures that will be followed in requesting interpretations of the Federal Standard COBOL and in providing responses to those requests. The provisions of this document apply to all Federal departments and agencies and to vendors of COBOL compilers in their dealings with the Federal Government.

**FIPS PUB 30. Software summary for describing computer programs and automated data systems**, B. Marron, Standards Coordinator, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 30, 5 pages (1974) SD Catalog No. C13.52:30.

Key words: computer programs; computers; computer software; data processing; Federal Information Processing Standards; information processing.

This publication provides a standard software summary form (SF-185) together with instructions for describing computer programs and/or automated data systems for identification, reference, and dissemination purposes. Federal Information Processing Standard Software Summary Form (SF-185) will be used in documenting summaries or abstracts of programs and/or automated data systems that are developed or acquired by Federal departments and agencies. This form will also be used by the General Services Administration in the establishment of a centralized registry of selected government software.



**FIPS PUB 31. Guidelines for automatic data processing physical security and risk management**, S. K. Reed, Ed., Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 31, 92 pages (1974) SD Catalog No. C13.52:31.

Key words: ADP security; computer reliability; contingency plans; Federal Information Processing Standard; fire safety; natural disasters; physical security; risk analysis; security audit; security awareness; supporting utilities.

This publication provides guidelines to be used by Federal organizations in structuring physical security programs for their ADP facilities. It treats security analysis, natural disasters, supporting utilities, system reliability, procedural measures and controls, off-site facilities, contingency plans, security awareness and security audit. It contains statistics and information relevant to physical security of computer data and facilities and references any applicable publications for a more exhaustive treatment of specific subjects.

**FIPS PUB 32. Optical character recognition character sets**, P. Mantek, Standards Coordinator, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 32, 78 pages (1974) SD Catalog No. C13.52:32.

Key words: alternate character; centerline drawings; character positioning; character sets; character shape; character sizes; font; lower case character; Optical Character Recognition; upper case character.

This standard provides the description, scope, and identification for standard sets of graphic shapes to be used in the application of Optical Character Recognition (OCR) systems. Two font styles, known as Style A and B, are described. Style A comprises a font of 92 characters which is designed to provide a maximum of machine efficiency in reading under a wide variety of applications. Style B comprises a font of 96 characters, which stresses esthetic appearance, but which may be applied under a substantial range of applications. Three sizes of characters designated as Size I, III and IV are presented. The basic requirements related to character positioning are also specified. Individual character drawings for both styles of character sets are included.

**FIPS PUB 33. Character set for handprinting**, R. E. Rountree, Standards Coordinator, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 33, 4 pages (1974) SD Catalog No. C13.52:33.

Key words: character sets; character shape; character sizes; Federal Information Processing Standards; handprinting; Optical Character Recognition.

This FIPS PUB announces the adoption of the American National Standard X3.45-1974, Character Set for Handprinting as a Federal Standard. This standard provides the description, scope, and application rules for a character set for handprinting. A major purpose of this standard is to reduce the cost of data input into ADP systems which use Optical Character Recognition (OCR) equipment.

## 3.12. PRODUCT STANDARDS

Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The purpose of the standards is to establish nationally recognized requirements for products, and to provide all concerned interests with a basis for common understanding of the characteristics of the products. The National Bureau of Standards administers the Voluntary Product Standards program as a supplement to the activities of the private sector standardizing organizations.

**PS57-73. Cellulosic fiber insulating board.** (ANSI A194.1-1973), K. G. Newell, Jr., Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 57-73, 8 pages (Nov. 1973) SD Catalog No. C13.20/2:57-73.

Key words: board, cellulosic fiber insulating; cellulosic fiber insulating board; fiber, cellulosic insulating board; insulating, cellulosic fiber board.

This Voluntary Product Standard covers requirements and applicable methods of test for the composition, construction, dimensions, moisture content, and physical properties of cellulosic fiber insulating board. Methods of identifying products which comply with this standard are included and information concerning surface finishes and edge details is given in appendix A. Supersedes CS42-49 and R179-63.

**PS58-73. Basic hardboard.** (ANSI A135.4-1973), K. G. Newell, Jr., Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 58-73, 6 pages (June 1974) SD Catalog No. C13.20/2:58-73.

Key words: basic hardboard; hardboard.

This Voluntary Product Standard covers requirements and methods of test for water resistance, modulus of rupture, tensile strength, surface finish, dimensions, squareness, edge straightness, and moisture content of five classes of basic hardboard. Methods of identifying hardboard that conforms to the standard are provided. Supersedes CS251-63.

**PS59-73. Prefinished hardboard paneling.** (ANSI A135.5-1973), K. G. Newell, Jr., Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 59-73, 7 pages (Feb. 1974) SD Catalog No. C13.20/2:59-73.

Key words: hardboard paneling; paneling, hardboard; prefinished hardboard paneling.

This Voluntary Product Standard covers requirements and methods of test for the dimensions, squareness, edge straightness, and moisture content of prefinished hardboard paneling; for the physical properties of the hardboard substrate; and for the finish of the paneling. Methods of identifying products which conform to the requirements of the standard are included.

**PS60-73. Hardboard siding.** (ANSI A135.6-1973), K. G. Newell, Jr., Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 60-73, 7 pages (Feb. 1974) SD Catalog No. C13.20/2:60-73.

Key words: hardboard siding; siding, hardboard.

This Voluntary Product Standard covers requirements and methods of test for the dimensions, straightness, squareness, physical properties, and surface characteristics of hardboard siding. Definitions of trade terms used and methods of identifying products that comply with the standard are included.

### 3.13. TECHNICAL NOTES

Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other Government agencies.

TN361. (Revised). Metric Supplement. **Liquid densities of oxygen, nitrogen, argon and parahydrogen**, H. M. Roder, Nat. Bur. Stand. (U.S.), Tech. Note 361 (Revised), (Metric Supplement), 114 pages (June 1974) SD Catalog No. C13.46:361 (Rev.), Metric Supplement.

Key words: argon; compressed liquid; density; density ratios; liquid; nitrogen, oxygen; parahydrogen; pressure; saturated liquid; tables; temperature; uncertainties; volume.

Tables of pressure, volume, density and temperature for the saturated liquid and for compressed liquid states from the triple point to the critical point, of oxygen, nitrogen, argon, and parahydrogen are presented. The table entries of temperature are in Kelvin and degrees Celsius, table entries in pressure are in bars and  $\text{kp/cm}^2$ . Volumes or densities are given in several different units, and density ratios are tabulated for each entry. Estimates of the uncertainty for the tabulated data are given. The tables were prepared in the style and in the units preferred by the users. They are intended as source for both technician and engineer.

TN594-6. **Optical radiation measurements: The present state of radiometry and photometry**, B. Steiner, Nat. Bur. Stand. (U.S.), Tech. Note 594-6, 56 pages (Mar. 1974) SD Catalog No. C13.46:594-6.

Key words: measurement system; photometry; professional societies; radiometry; standards.

The electro-optics industry and the public that depends on it are part of an informal but influential system for optical radiation measurement. The growth of this industry and of public concerns related technically to it have put severe new strains on this measurement system. The system itself must therefore be analyzed. The state of the art, on which the measurement system depends, is surveyed in terms of basic measurement parameters. The measurement system is analyzed in terms of its three basic components: the flow of physical standards, the generation of procedural standards, and the funding framework. The roles of the professional society and of the Council for Optical Radiation Measurement are reviewed. New requirements of the system are identified. Finally, the methodology of the study is reviewed in detail.

TN594-7. **Optical radiation measurements: Approximate theory of the photometric integrating sphere**, W. B. Fussell, Nat. Bur. Stand. (U.S.), Tech. Note 594-7, 39 pages (Mar. 1974) SD Catalog No. C13.46:594-7.

Key words: illuminance distribution; integrating sphere; lamp comparisons; photometric accuracy; photometry; total luminous flux.

An approximate mathematical theory of the photometric integrating sphere is developed. The analysis is accurate to the first order in the ratio of the baffle area to the sphere wall area. The sphere is assumed to be occupied by a circular baffle and a spherical lamp; the centers of the baffle and the lamp lie on a diameter of the sphere. The surfaces of the sphere and the baffle are as-

sumed to reflect in a uniformly diffuse manner. The lamp is assumed to absorb a fraction of the radiation incident upon it, and to transmit (or specularly reflect) the remainder. The luminance distribution at the sphere window is derived for a general source input at any point of the sphere wall. A model lamp illuminance distribution is assumed, and a formula for the fractional error in comparing the total luminous fluxes of two lamps in the integrating sphere, is derived. The physical significance of the formula is described.

TN594-8. **Tables of diffraction losses**, W. B. Fussell, Nat. Bur. Stand. (U.S.), Tech. Note 594-8, 39 pages (June 1974) SD Catalog No. C13.46:594-8.

Key words: diffraction; diffraction losses; Fresnel diffraction; Kirchhoff diffraction theory; photometry; radiometry; scalar diffraction theory.

Tables of diffraction losses are given for a range of typical experimental geometries for wavelengths from 0.2 to 100 micrometers. The scaling relationships for the diffraction losses for varying wavelengths and geometries are also given, and sample calculations are presented. General formulas are given for the diffraction losses; the formulas are derived from the Kirchhoff scalar paraxial diffraction theory. The accuracy of the tabulated values is estimated.

TN594-9. **Optical radiation measurements: Describing spectrophotometric measurements**, W. H. Venable, Jr., and J. J. Hsia, Nat. Bur. Stand. (U.S.), Tech. Note 594-9, 49 pages (Nov. 1974) SD Catalog No. C13.46:594-9.

Key words: accuracy; appearance; colorimetry; definition of spectrophotometry; error analysis; photometry; radiation transfer; reflectance; scattering; spectrophotometry; transmittance.

A general method is presented to describe spectrophotometric measurements mathematically. All space is divided into instrument space or sample space. Idealized absolute and relative measurements are defined at the boundary between the instrument and sample space by four descriptors: a radiance input  $L$ , a scattering function  $S$ , a relative responsivity  $R$ , and a scaling function  $K$ . Real measurements are also defined at the boundary and described by these four descriptors, and general expressions for fractional error are derived. A 45-degree, 0-degree reflectance measurement is used as a specific example to illustrate an application of this method to describing measurements and performing an error analysis.

TN616. Revised March 1974. **Frequency standards and clocks: A tutorial introduction**, H. Hellwig, Nat. Bur. Stand. (U.S.), Tech. Note 616 (Revised), 72 pages (Mar. 1974) SD Catalog No. C13.46:616 (Rev.).

Key words: cesium beam; clocks (atomic); crystal oscillator; frequency accuracy; frequency stability; frequency standards; hydrogen maser; quartz crystal; rubidium gas cell; timekeeping.

The topic of frequency standards and clocks is treated in a tutorial and nonmathematical way. The concepts of time, frequency stability, and accuracy are introduced. The general physical principles and design features of frequency standards and clocks are described. The design, performance, and limitations of quartz crystal oscillators and atomic devices (cesium, hydrogen, rubidium) are discussed in detail and critically compared for laboratory



devices as well as for devices intended for field usage.

**TN646. Status report on primary frequency standards**, H. Hellwig, Nat. Bur. Stand. (U.S.), Tech. Note 646, 15 pages (Sept. 1973) SD Catalog No. C13.46:646.

Key words: accuracy; atomic frequency standards; cesium beam tubes; clocks; hydrogen masers; lasers; primary frequency standards.

This report surveys the state-of-the-art in atomic frequency standards with exclusive regard to their use as primary frequency reference; i.e., only accuracy is discussed. The report covers operational standards as well as devices which are still in the research or exploratory development phase. It is predicted that accuracies of better than  $1 \times 10^{13}$  will be achieved within a few years, and that, as a consequence of new techniques, accuracy may be treated statistically in the not too distant future. Also, clocks may become available which state accuracy continually.

**TN647. Microwave attenuation measurement system (series substitution)**, W. Larson and E. Campbell, Nat. Bur. Stand. (U.S.), Tech. Note 647, 28 pages (Feb. 1974) SD Catalog No. C13.46:647.

Key words: attenuation; measurement; rotary-vane attenuator; series substitution.

A dual detection microwave bridge circuit has been incorporated in a series substitution system for the measurement of microwave attenuation devices. The use of an optical rotary-vane attenuator in the system yields practical resolution and stability of 0.00005 dB from zero to 30 dB. The dual detection system has several favorable features: (1) it employs a single microwave source which reduces cost, (2) measurements are obtained without power stabilization of the microwave signal source, and (3) this waveguide configuration enables measurements of attenuation devices at any length with minimum of effort and movement of waveguide components.

The system configuration is convenient for both attenuation difference, and insertion loss measurements from zero to 70 dB over the WR90 waveguide band of 8.2 to 12.4 GHz.

**TN648. Thermophysical properties of nitrogen from the fusion line to 3500 R (1944 K) for pressures to 150,000 psia ( $10342 \times 10^5$  N/m<sup>2</sup>)**, R. T. Jacobsen, R. B. Stewart, R. D. McCarty, and H. J. M. Hanley, Nat. Bur. Stand. (U.S.), Tech. Note 648, 162 pages (Dec. 1973) SD Catalog No. C13.46:648.

Key words: density; dielectric constant; enthalpy; entropy; equation of state; fixed points; heat transfer coefficients; index of refraction; Joule-Thomson; latent heat; melting point; nitrogen; Prandtl number; specific heat; speed of sound; surface tension; thermal conductivity; thermal diffusivity; vapor pressure; viscosity; volume.

Tables of thermophysical properties of nitrogen are presented for temperatures from the fusion line to 3500 R for pressures to 3000 psia, and from the fusion line to 1500 R for pressures above 3000 psia to 150,000 psia. The tables include values of entropy, enthalpy, internal energy, density, specific volume, velocity of sound, specific heats ( $C_v$  and  $C_p$ ), thermal conductivity, viscosity, thermal diffusivity, Prandtl number, and the dielectric constant for selected isobars. Additional tables are included for values of:  $(\partial P/\partial V)_T$ ,  $(\partial P/\partial T)_\rho$ ,  $V(\partial H/\partial V)_\rho$ ,  $(\partial P/\partial U)_v$ ,  $V(\partial P/\partial V)_T$ , and  $(\partial V/\partial T)_p$ , which have special utility in heat transfer calculations. Tables of selected isobars for the liquid and vapor phases, and for the saturated vapor and saturated liquid are included.

An equation of state is presented for liquid and gaseous nitrogen for the temperature and pressure ranges of these tables. In the determination of the equation of state, all of the P- $\rho$ -T (pressure-density-temperature) data available from the published

literature were reviewed, and appropriate corrections made to bring experimental temperatures into accord with the International Practical Temperature Scale of 1968. The coefficients of the equation of state were determined by a weighted least squares fit to selected P- $\rho$ -T data and simultaneously to  $C_p$  data determined by corresponding states analysis from oxygen data, and to data which defined the phase equilibrium criteria for the saturated liquid and saturated vapor. A vapor pressure equation, melting curve equation, and an equation to represent the ideal gas heat capacity of nitrogen are also presented. The equation of state is estimated to be accurate to within 0.5 percent in the liquid region, to within 0.1 percent for supercritical isotherms up to 15,000 psia, and to within 0.3 percent from 15,000 to 150,000 psia. The vapor pressure equation is accurate to within  $\pm 0.01$  K between the triple point and the critical point.

**TN649. The standards of time and frequency in the U.S.A.**, J. A. Barnes and G. M. R. Winkler, Nat. Bur. Stand. (U.S.), Tech. Note 649, 91 pages (Feb. 1974) SD Catalog No. C13.46:649.

Key words: astronomical time measurements; clock synchronization; clocks; Coordinated Universal Time (UTC); frequency; frequency standards; International Atomic Time (TAI); International Radio Consultative Committee (CCIR); International Scientific Radio Union (URSI); International Time Bureau (BIH); international time organizations; leap seconds; national time/frequency standards; NBS time and frequency; Precise Time and Time Interval (PTTI); time; time coordination; time interval; time scales; Treaty of the Meter (standards); U.S.A. standard time zones; USNO time and frequency.

This paper describes the national responsibilities for standards of time and frequency in the U.S.A. The National Bureau of Standards (NBS) and the U.S. Naval Observatory (USNO) are the two organizations chiefly involved in distributing accurate and precise time and frequency information within the U.S.A. The NBS is responsible for the "custody, maintenance, and development of the national standards" of frequency and time (interval) as well as their dissemination to the general public. The mission of the USNO includes the "provision of accurate time" for electronic navigation systems, communication, and space technology. This is an integral part of its work concerned with the publication of ephemerides which are used in support of navigation and in the establishment of a fundamental reference system in space.

Both agencies provide the U.S. contribution to the Bureau International de l'Heure (BIH) [International Time Bureau], which has the responsibility of publishing definitive values of Universal Time (UT), International Atomic Time (TAI), and Coordinated Universal Time (UTC).

**TN650. An evaluation of selected angular momentum, vortex shedding and orifice cryogenic flowmeters**, J. A. Brennan, R. W. Stokes, C. H. Kneebone, and D. B. Mann, Nat. Bur. Stand. (U.S.), Tech. Note 650, 69 pages (Mar. 1974) SD Catalog No. C13.46:650.

Key words: angular momentum; cryogenic; flow; liquid nitrogen; mass; mass flowmeters; measurement; orifice; volume flowmeters; vortex shedding.

The National Bureau of Standards (NBS) and the Compressed Gas Association (CGA) have jointly sponsored a research program on cryogenic flow measurement. Cryogenic flowmeters operating on the principles of angular momentum (mass flow), vortex shedding (volume flow), and pressure drop are reported.

The operation and the accuracy of the flow facility is briefly described. The performance of the flowmeters in liquid nitrogen is described by reporting the precision and bias of the meters before and after an 80-hour stability test and by defining the ex-



istence of temperature, pressure, flow rate, subcooling, and time order (wear) dependencies.

Meters were evaluated with flow rates ranging from 20 to 210 gpm (0.00126 to 0.0132 m<sup>3</sup>/s), pressures ranging from 32 to 112 psia (0.22 to 0.77 MPa), and with temperatures ranging from 72 to 90 K.

**TN651. Scattering-matrix description and near-field measurements of electroacoustic transducers**, D. M. Kerns, Nat. Bur. Stand. (U.S.), Tech. Note 651, 40 pages (Mar. 1974) SD Catalog No. C13.46:651.

Key words: electroacoustic transducer measurement techniques; near-field measurement techniques; scattering matrix description of electroacoustic transducers.

Recently developed and successfully applied analytical techniques for the measurement of microwave antennas at reduced distances are "translated" into corresponding techniques for the measurement of electroacoustic transducers in fluids. The basic theory is formulated in scattering-matrix form and emphasizes the use of plane-wave spectra for the representation of sound fields. This theory, in contrast to those based on asymptotic description of transducer characteristics, is suitable for the formulation and solution of problems involving interactions at arbitrary distances. Two new techniques (in particular) are described: One, utilizing deconvolution of planar scanning data, taken with a known transducer at distances  $d$  which may be much less than the Rayleigh distance  $d_R$  ( $= D^2/2\lambda$ ), provides a means of obtaining complete effective directivity functions, *corrected for the effects of the measuring transducer*. Applicability of a (two-dimensional, spatial) sampling theorem and the "fast Fourier transform" algorithm, which greatly facilitate the necessary computations, is shown. The second technique provides a means of extrapolating received signal as a function of distance (observed with  $d \sim d_R$ ) to obtain on-axis values of effective directivity. Other possible applications are indicated. These techniques rigorously utilize observed output of nonideal (but linear) measuring transducers.

**TN652. Development and construction of an electromagnetic near-field synthesizer**, F. M. Greene, Nat. Bur. Stand. (U.S.), Tech. Note 652, 44 pages (May 1974) SD Catalog No. C13.46:652.

Key words: electromagnetic-field hazards; electromagnetic-field synthesizer; electromagnetic radiation-exposure testing (non-ionizing); near fields; RF biological hazards.

This publication describes work done by the National Bureau of Standards for the USAF School of Aerospace Medicine at Brooks AF Base involving the development, design, construction and testing of a prototype EM near-field synthesizer. The purpose of the contract was to provide a means of independently generating high-level electric and magnetic near fields in the frequency range 10 to 30 MHz. These fields are to be used in various ratios by the USAFSAM in their EM radiation exposure program for determining the biological effects of hazard-level, non-ionizing EM fields on human beings.

The synthesizer consists of a balanced, parallel-plate strip line to generate the "desired" electric field, and a single-turn quadruple-feed inductor placed parallel to and midway between the plates to generate the "desired" magnetic field. Methods used to reduce the "unwanted" E- and H-field components associated with the above, as well as the methods used to reduce the coupling between the two field systems are discussed. The result is a synthesizer in which the electric- and magnetic-field components can be adjusted essentially independently over wide ranges of magnitude, relative time-phase, and spatial orientation to simulate various near-field configurations.

Previous research has been largely limited to the use of plane-wave fields for evaluating RF biological hazards. This new device will allow researchers to investigate any near-field effects that may occur at high field levels.

**TN653. The thermophysical properties of methane, from 90 to 500 K at pressures to 700 bar**, R. D. Goodwin, Nat. Bur. Stand. (U.S.), Tech. Note 653, 280 pages (Apr. 1974) SD Catalog No. C13.46:653.

Key words: densities; enthalpies; entropies; equation of state; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; PVT data; specific heats; speeds of sound; vapor pressures.

Thermophysical properties of methane are tabulated at uniform temperatures from 90.68 to 500 K along isobars to 700 bar. A novel equation of state is employed for the first time, having origin on the vapor-liquid coexistence boundary. Computations are based almost entirely on ideal gas specific heats and experimental P- $\rho$ -T data via the equation of state, without weighting to data for derived properties. Good agreement with such data confirms validity of the equation and method. New P- $\rho$ -T data are reported at 0.3 to 1.7 times the critical density.

**TN654. Electromagnetic noise in Robena No. 4 coal mine**, W. D. Bensema, M. Kanda, and J. W. Adams, Nat. Bur. Stand. (U.S.), Tech. Note 654, 194 pages (Apr. 1974) SD Catalog No. C13.46:654.

Key words: amplitude probability distribution; coal mine noise; digital data; electromagnetic interference; electromagnetic noise; emergency communications; Fast Fourier Transform; Gaussian distribution; impulsive noise; magnetic field strength; measurement instrumentation; spectral density; time-dependent spectral density.

Two different techniques were used to make measurements of the absolute value of electromagnetic noise in an operating coal mine, Robena No. 4, located near Waynesburg, Pa. One technique measures noise over the entire electromagnetic spectrum of interest for brief time periods. With present instrumentation, the spectrum can be covered from 40 Hz to 400 kHz. It is recorded using broad-band analog magnetic tape, and the noise data are later transformed to give spectral plots. The other technique records noise envelopes at several discrete frequencies for a sufficient amount of time to provide amplitude probability distributions.

The specific measured results are given in a number of spectral plots and amplitude probability distribution plots. The general results are that at frequencies below 10 kHz, power line noise within the mine is severe. Impulsive noise is severe near arcing trolleys, and at lower frequencies near any transmission line. Carrier trolley phone signals and harmonics are strong throughout the mine whenever the trolley phone is in operation.

Additional information beyond that included in this report may be obtained from the authors, who are with the Electromagnetics Division of the National Bureau of Standards.

**TN655. Cryogenic refrigerators—an updated survey**, T. R. Strobridge, Nat. Bur. Stand. (U.S.), Tech. Note 655, 12 pages (June 1974) SD Catalog No. C13.46:655.

Key words: cost; cryogenic refrigerators; efficiency; volume; weight.

In 1969, we gave efficiency, weight, volume, and cost data for 95 cryogenic refrigerators and liquefiers excluding air separation plants. Recently, the survey was repeated. The original data and those for 49 additional refrigerators and liquefiers are presented



spanning refrigeration capacities from 0.2 to  $10^6$  W and temperatures from 1.85 to 90 K. Generally, there is no change in the trends exhibited by the older data except that the high temperature, low capacity new units seem to be larger, heavier, and slightly less efficient than in prior years. Presumably, these effects are due to efforts to increase useful life and reliability. Costs remain the same as predicted before even though no dollar value adjustments were made.

**TN656. Standard time and frequency: Its generation, control, and dissemination by the National Bureau of Standards, J. B. Milton, Nat. Bur. Stand. (U.S.), Tech. Note 656, 21 pages (June 1974) SD Catalog No. C13.46:656.**

Key words: clock synchronization; frequency and time dissemination; primary frequency standard; standard frequency broadcasts; time interval; time scales.

The Time and Frequency Division of the National Bureau of Standards maintains primary frequency standards, which provide a realization of the internationally-defined second, and two atomic time scales, AT(NBS) and UTC(NBS). AT(NBS) is dependent upon the primary frequency standards, an ensemble of commercial cesium clocks, and a computer algorithm to process the data. The UTC(NBS) scale is derived from AT(NBS) by the addition of small annual frequency adjustments and leap second adjustments to keep its time nominally synchronous with the international time scale UTC. The UTC(NBS) time scale is used to calibrate the clocks and secondary standards necessary for the operation of the NBS radio stations, WWV, WWVH, WWVB, and WWVL. These stations transmit various standard frequency and time signals throughout the world, and, in addition, provide certain official announcements such as geoalert warnings, marine weather advisories, and radio propagation forecasts.

**TN657. Calculated and measured  $S_{11}$ ,  $S_{21}$ , and group delay for simple types of coaxial and rectangular waveguide 2-port standards, R. W. Beatty, Nat. Bur. Stand. (U.S.), Tech. Note 657, 67 pages (Dec. 1974) SD Catalog No. C13.46:657.**

Key words: Automatic network analyzers; coaxial; coaxial line step discontinuities; group delay; scattering coefficients; standards; 2-ports; waveguide; waveguide discontinuities.

Formulas, simple computer programs, graphs and tables are given to aid in the design and construction of 2-port standards for rectangular waveguide and coaxial line. Only standards consisting of reduced height waveguide, increased ODIC (outside diameter of inner conductor), or reduced IDOC (inside diameter of outer conductor) coaxial line are considered. Examples of the calculation of  $S_{11}$ ,  $S_{21}$  and group delay, and their measurement with automatic network analyzers are given. Some of the important sources of error in the standards are discussed and design data are presented for specific standards.

**TN661. Advances in the measurement of rf power and attenuation using SQUIDS, R. A. Kamper, M. B. Simmonds, R. T. Adair, and C. A. Hoer, Nat. Bur. Stand. (U.S.), Tech. Note 661, 27 pages (Sept. 1974) SD Catalog No. C13.46:661.**

Key words: Josephson effect; quantum interference; rf attenuation; rf measurement; rf power; superconductivity.

This report covers the progress made in the application of Superconducting Quantum Interference Devices (SQUIDS) to the measurement of rf power and attenuation during the year from July 1973 to June 1974. The earlier work on this project was reported in NBS Technical Note 643, which contains a detailed introduction to the principles involved. We will assume the reader to be familiar with the material we presented there, since we do

not repeat it in this report. In order to make the connection as smooth as possible, we have retained our earlier chapter titles as far as possible.

During the year we have developed stable SQUIDS with preset junctions which survive thermal cycling and mechanical shock. Further work is required to arrive at a version suitable for precise rf measurements. We have assembled a "breadboard" system capable of measuring rf power at levels down to  $10^{-15}$  W in the range of frequency from 100 MHz to 1 GHz. We have extended the dynamic range of our system to measure rf attenuation to 60 dB, and developed the hardware to partially automate its operation and to accommodate step attenuators. We have tested a portable version of this system, and are in process of designing an improved version based on what we learned from the first one.

**TN782. Application of systems analysis to the operation of a fire department, E. K. Nilsson, J. A. Swartz, and M. Westfall, Nat. Bur. Stand. (U.S.), Tech. Note 782, 52 pages (June 1974) SD Catalog No. C13.46:782.**

Key words: Alexandria; fire department; location; operations research; resource allocation; simulation; systems analysis.

Rising labor costs and increasing competition for tax dollars to provide urban services demand that a more precise methodology be used in the management of fire departments. A pilot program was conducted with the cooperation of the Alexandria, Va. Fire Department to evaluate the applicability and usefulness of selected Operations Research tools. These tools, in the form of computer models, were modified and adapted to assure that they could be implemented to provide information which would facilitate fire department management. In this effort queuing, facility location, and simulation models were applied to sample data extracted from the historical records of the Alexandria Fire Department. It was established that such models do provide valuable information which may assist managerial decisions. This paper describes the city of Alexandria and its fire department, the O.R. models, output from their application, and evaluations of the output.

**TN800. Computer networking: Approaches to quality service assurance, R. B. Stillman, Nat. Bur. Stand. (U.S.), Tech. Note 800, 26 pages (Jan. 1974) SD Catalog No. C13.46:800.**

Key words: compiler; computer network; documentation; dynamic software analysis; interpreter; quality control; software testing; software verification; static software analysis; structured programming; system errors; system performance; theorem-proving.

The problem of quality service assurance in a (generalized) computer networking environment is addressed. In the absence of any direct, well-defined, quantitative measure of service quality and reliability, error collection and analysis is the only basis for service quality control. Therefore, mechanisms are described which facilitate reporting of operational errors, documentation of error corrections, and collection of system performance data. Since techniques for hardware quality control are well known, these mechanisms focus on collecting data which can be used to assess and control software quality. Finally, specific network facilities are described which support research in the area of software quality, and potential areas of new research using the network are identified.

**TN801. Research considerations in computer networking to expand resource sharing, D. W. Fife, Nat. Bur. Stand. (U.S.), Tech. Note 801, 24 pages (June 1974) SD Catalog No. C13.46:801.**



**Key words:** computer networking research; computer network management; management evaluation; resource sharing.

Computer networking technology is adequately developed now to support research and experimentation to expand computing resource sharing. Whether progress will be made depends upon organizational initiative among multiple institutions, to pool personnel and capital so as to effectively address the major issues in management approach, support and software design that limit the feasible interdependence of computing operations. The organizational requirements are partially revealed by examining progressive stages of resource sharing in organizational and operational terms rather than such technical aspects as load sharing or program sharing that have been introduced in the past. Five stages are identified, ranging from simply establishing multiple service access to the advanced stage where multiple institutions organize for joint development of new resources. A preliminary evaluation framework for new management arrangements results when these stages are mapped against the four functional levels inherent in computer network management. Future needs for networking experimentation and research are briefly described, and other NBS technical results are identified in context.

**TN803. A guide to networking terminology**, A. J. Neumann, Nat. Bur. Stand. (U.S.), Tech. Note 803, 29 pages (Mar. 1974) SD Catalog No. C13.46:803.

**Key words:** computer networks; glossary; telecommunications; teleprocessing; terminology; vocabulary.

A selected set of terms and definitions relating to computer networking is presented in a coherent manner. An introduction gives the rationale for the glossary, defines the scope by a brief tutorial overview, and states the glossary format and conventions. The glossary is arranged alphabetically and contains about 140 definitions and associated terms. The sources of many terms are cited and modifiers indicate the status of definitions. A complete listing of source material is appended.

**TN804. Review of computer networking technology**, R. P. Blanc, Nat. Bur. Stand. (U.S.), Tech. Note 804, 135 pages (Jan. 1974) SD Catalog No. C13.46:804.

**Key words:** computer networks; computer-to-computer transfers; interactive terminals; minicomputer-based systems; network configuration; remote job entry; resource sharing.

This report gives a descriptive summary of the technical characteristics of existing computer networks, including data communication technology and configuration related to support of resource sharing services for a computer network. Included are discussions of terminal support capabilities for the communications network and a development of relevant network terminology. The report concludes with a comparative evaluation of existing technological approaches to networking.

**TN805. Network management survey**, I. W. Cotton, Nat. Bur. Stand. (U.S.), Tech. Note 805, 91 pages (Feb. 1974) SD Catalog No. C13.46:805.

**Key words:** computer network; management; network, network management.

This report presents the results of a study of management practices in different computer networks. Five networks were chosen as typical of different approaches to network implementation and management: Defense Advanced Research Projects Agency (ARPA) Network, MERIT Network, Triangle Universities Computation Center (TUCC), Oregon State Regional Network and Tymnet, a commercial network. A common format is employed to survey each network. While the report is not in-

tended to be prescriptive, some empirical observations are presented for each topic covered.

**TN809. Government looks at privacy and security in computer systems. A summary of a conference held at the National Bureau of Standards, Gaithersburg, Maryland, November 19-20, 1973**, C. R. Renninger and D. K. Branstad, Eds., Nat. Bur. Stand. (U.S.), Tech. Note 809, 47 pages (Feb. 1974) SD Catalog No. C13.46:809.

**Key words:** computer systems, privacy and security; confidentiality; privacy; security.

This publication summarizes the proceedings of a conference held for the purpose of highlighting the needs and problems of Federal, State and local government in safeguarding individual privacy and protecting confidential data contained in computer systems from loss or misuse. The Conference was held at the National Bureau of Standards on November 19-20, 1973.

The origin of governmental problems is discussed in the context of the public's concern for privacy arising out of computer-based recordkeeping, the diverse legislative actions now being taken to safeguard privacy, the threats to the security of computer-based information systems and the technological problems associated with protecting against such threats. Useful distinctions are drawn between privacy, confidentiality and security to clarify the issues and allocate responsibilities for solving the problem among lawmakers, technologists and management.

Major needs are described. These include the need for cohesive Federal, State and local legislation, technological guidelines and standards for assuring uniform compliance with legislative requirements; management guidelines for identifying and evaluating threats to security; and improved technological mechanisms for controlling access to computer systems and networks. Cost implications of providing security measures are discussed.

**TN811. Evaluation of the column connections used in a precast concrete modular housing system**, F. Y. Yokel and T. W. Reichard, Nat. Bur. Stand. (U.S.), Tech. Note 811, 63 pages (Mar. 1974) SD Catalog No. C13.46:811.

**Key words:** building system; column connection; concrete triaxial strength; ductility; neoprene bearing pad; Operation Breakthrough; performance test; precast concrete; structural design.

The column connections used in a housing system employing stacked precast concrete box modules were tested to evaluate their structural performance. The system was proposed for construction in Operation Breakthrough, a research and demonstration program sponsored by the Department of Housing and Urban Development. The system uses innovative structural design concepts, which include: confinement of the concrete in the vicinity of the column bearings by reinforcing ties in order to increase concrete compressive strength; neoprene pads between column bearings in the upper stories; steel-neoprene-steel sandwich in the lower stories; and a grouted dowel through the center of the columns to provide resistance to tension and shear.

The test program included the following: tests to determine the effect of various bearing pads on the load capacity of the connection; tests to determine the load-deformation characteristics of the neoprene pads; a test to determine the performance of a lower-story connection using a steel-neoprene-steel sandwich and a grouted dowel; and tests to evaluate the strength and ductility of the connections when subjected to a shear force. The test results are presented and interpreted and the findings are summarized. Supersedes NBSIR 73-148 (PB 220366/7).

**TN812. Tensile behavior of boron/epoxy-reinforced 7075-T6 aluminum alloy at elevated temperatures**, D. J. Chwirut and G. F.



Sushinsky, Nat. Bur. Stand. (U.S.), Tech. Note 812, 31 pages (Mar. 1974) SD Catalog No. C13.46:812.

Key words: aluminum alloy; boron/epoxy; co-cure; composite materials; fabrication process; load-deformation characteristics; residual stress; rule of mixtures; sandwich specimen; stress-strain curves; tensile properties.

Static tensile tests were performed on specimens of 7075-T6 aluminum alloy, 0° unidirectional boron/epoxy, and 7075-T6 aluminum alloy reinforced on the surface with 0° unidirectional boron/epoxy laminate, at four temperatures up to 300 °F (149 °C). Analytical load-strain curves are formulated for the reinforced-metal specimens using the rule of mixtures, assuming that the longitudinal strains in the composite and the metal remain equal, and taking account of the residual stresses caused by the fabrication process. Two analytical curves are plotted for each reinforced-metal specimen, one based on the measured ply thickness of the composite, and one based on a nominal 0.005-in (0.13-mm) ply thickness. In general, the experimental load-strain curves fall between the two analytical curves for each specimen.

**TN813. NBS Reactor: Summary of activities July 1972 to June 1973**, R. S. Carter, Nat. Bur. Stand. (U.S.), Tech. Note 813, 135 pages (Feb. 1974) SD Catalog No. C13.46:813.

Key words: activation analysis; crystal structure; diffraction; isotopes; molecular dynamics; neutron; nuclear reactor; radiation.

This report summarizes all those programs which depend on the NBS reactor. It covers the period from July 1972 through June 1973. The programs range from the use of neutron beams to study the structure and dynamics of materials through nuclear physics and neutron standards to sample irradiations for activation analysis, isotope production and radiation effects studies.

**TN814. A mechanized information services catalog**, B. Marron, E. Fong, and D. Fife, Nat. Bur. Stand. (U.S.), Tech. Note 814, 56 pages (Feb. 1974) SD Catalog No. C13.46:814.

Key words: bibliographic data bases; computer-based systems; information services; information systems.

NBS is mechanizing a catalog of currently available information sources and services. Information from recent surveys of machine-readable, commercially-available bibliographic data bases, and the various current awareness, batch retrospective, and interactive retrospective services which can access them, has been correlated and converted into a machine-readable data base. A prototype searching capability has been established on an operational interactive retrieval system. Reasons for establishing the catalog and the choice of the initial information are detailed and the prototype implementation is described. Sample queries are included, as well as a to-date listing of the catalog. Plans for future development are discussed.

**TN815. Fire accidents involving the ignition of sleepwear worn by children under the age of three**, E. A. Tyrrell, Nat. Bur. Stand. (U.S.), Tech. Note 815, 23 pages (Feb. 1974) SD Catalog No. C13.46:815.

Key words: accidents; burn injuries; case histories; children's sleepwear; fabric fires; FFACTS; fires; flammable fabrics; garment fires; ignition sources; standards.

Accident case histories of children under age 3 involved in sleepwear fires are examined in detail. Of 434 persons involved in sleepwear ignition incidents in the NBS Flammable Fabrics Accident Case and Testing System as of January 1973, 101 were children under age 6; 22 of these were children under age 3. In 15 of these 22 accidents, the child was a victim of his own actions, while in 7 more accidents, the child played a passive role in the ignition sequence. Matches and kitchen ranges were the

most frequent ignition sources found for this group of children. Seven of these small children died; the remaining 15 victims sustained burn injuries covering from one to 65 percent of their bodies. Most of the sleepwear items involved in these 22 accidents were made of cotton and 14 of these 22 items were pajamas. Children under age 3 were most frequently involved in fire accidents during the morning hours in the kitchen or bedroom. Only one child was under the supervision of an adult at the time of the accident. From the information found in the case history reports, an analysis of the severity of the injuries received by the victims was made and it was determined that the severity of the injuries received by one of the 3 infants under the age of one and 15 of the remaining 19 one- and two-year-olds probably would have been reduced if they had been afforded the protection of a flammability standard.

**TN816. Engineering and construction manual for an instrument to make burn hazard measurements in consumer products**, L. A. Marzetta, Nat. Bur. Stand. (U.S.), Tech. Note 816, 48 pages (Feb. 1974) SD Catalog No. C13.46:816.

Key words: consumer products; contact temperature; thermesthesiometer; thermometry.

Surface temperature measurement alone is insufficient to establish the hazard of human contact with a hot or cold object. A metal surface is more likely to cause thermal injury than a plastic surface at the same temperature. An instrument equipped with a measuring probe has been developed for indicating the tissue temperature that would be experienced if human contact were made with the hot surface in question. The correct value of interface contact temperature can be read for a selected contact time without knowing the composition or temperature of the heated material under test.

A detailed set of instructions and drawings for assisting in the construction of the device is included in the manual. Several test procedures are described for use in checking the performance of the measuring probe and instrument.

**TN817. Kitchen ranges in fabric fires**, A. K. Vickers, Nat. Bur. Stand. (U.S.), Tech. Note 817, 23 pages (Apr. 1974) SD Catalog No. C13.46:817.

Key words: accidents; burns; FFACTS; flammable fabrics; garments; ignition sources; injuries; kitchen ranges.

Kitchen ranges played a major role in the 1616 fabric accident case histories recorded in the Flammable Fabrics Accident Case and Testing System as of May 1972. They accounted for 214 or 35 percent of the direct garment ignitions in FFACTS. Female victims outnumbered males by 3 to 1; females under 16 and over 65 were particularly heavily represented. Reaching over and leaning against the range caused the majority of the garment ignitions. Shirts, robes, pajamas, nightgowns and dresses were the most frequently ignited garments. Thirty-four victims died from injuries resulting from garment ignitions from ranges; 24 of these fatalities were people over 65 years old.

**TN818. Occupant behavior in building fires**, A. I. Rubin and A. Cohen, Nat. Bur. Stand. (U.S.), Tech. Note 818, 28 pages (Feb. 1974) SD Catalog No. C13.46:818.

Key words: disaster research; high rise building fires; occupant safety.

Fire safety in buildings is important in building design and the formulation of codes and standards. However, an examination of the information concerning the *needs* of occupants in fire emergencies (as opposed to ensuring a degree of structural integrity for the building) indicates that the scientific information base is woefully inadequate. The increasing prominence of high rise buildings having many occupants intensifies the need for better



information about the behavior of occupants during fire emergencies. Fire researchers have indicated that it is often not feasible to evacuate buildings because of time constraints. Instead, designers use techniques such as safe areas within buildings and requiring people to respond differentially, based on their particular location. This approach emphasizes communications and warning systems to transmit messages. These systems such as loud noises or blinking lights should be designed to "take advantage" of the usual responses made by people. Occupants can actively be a part of the fire warning and fighting system instead of being unwilling victims. This possibility is pursued and a human factors approach is taken to suggest some means of better understanding the capabilities of occupants.

**TN819. A technical index of interactive information systems, D. W. Fife, K. Rankin, E. Fong, J. C. Walker, and B. A. Marron, Nat. Bur. Stand. (U.S.), Tech. Note 819, 73 pages (Mar. 1974) SD Catalog No. C13.46:819.**

Key words: bibliographic systems; computer programs; computer systems; data base; data management; information retrieval; information services; interactive system, query language; software selection; text processing.

This report constitutes a reference to technical features and operational status of interactive information systems, i.e. those providing a "conversational" usage mode to a "non-programmer" through a data terminal device. It is aimed at the ADP service manager, for his use in the state-of-the-art assessments preparatory to a detailed system selection process. It contains an index that describes 46 systems in terms of a list of over 50 technical features plus descriptive, identification, and background information. In addition, there are aids and examples contributing to the intended use of the index.

**TN820. Complete clear text representation of scientific documents in machine-readable form, B. C. Duncan and D. Garvin, Nat. Bur. Stand. (U.S.), Tech. Note 820, 55 pages (Feb. 1974) SD Catalog No. C13.46:820.**

Key words: graphic character sets; information analysis centers; information interchange codes; recording typewriters; scientific computer technology.

Science and technology use a large variety of symbols to represent physical properties, chemical formulas and mathematical expressions.

Data centers that codify and evaluate physical properties need to use this conventional symbolism in their work. It is recommended that these data centers adopt the symbols and terminology specified by the various International Unions both in manual operations and in the creation of machine-readable data bases.

It is demonstrated that these conventional symbols can be produced by modern communications devices that are compatible with the international standard codes for information interchange. A set of characters suitable for representing scientific data and text is presented and proposed as an extension of the ISO information interchange code.

The use of this extended character code by computer oriented data centers at the National Bureau of Standards is described. The equipment needed for this level of performance and criteria for their selection are outlined.

**TN821. Photometric data variability of automotive lighting components, B. G. Simson and J. Mandel, Nat. Bur. Stand. (U.S.), Tech. Note 821, 15 pages (Mar. 1974) SD Catalog No. C13.46:821.**

Key words: Federal Motor Vehicles Safety Standards; interlaboratory test evaluation; motor vehicles; photometric testing; safety standards.

Four automotive lighting components were tested in three commercial testing laboratories to estimate the degree of photometric data repeatability and reproducibility. The laboratories used the photometric testing techniques required by Federal Motor Vehicle Safety Standard No. 108. The precision of this test method was placed in a range of about 10 percent coefficient of variation. However, this value should be considered more as an indication of existing conditions than as a predictive parameter.

**TN822. A review of Federal and military specifications for floor coverings, W. C. Wolfe, Nat. Bur. Stand. (U.S.), Tech. Note 822, 99 pages (Apr. 1974) SD Catalog No. C13.46:822.**

Key words: carpets; floor coverings; government; performance; procurement; specifications; standards; tests; user needs.

In this manual, which is organized so as to aid ready reference, requirements and test methods in Federal and military specifications for flooring, or floor coverings are combined, indexed and reviewed. The manual covers carpet, resilient flooring, monolithic surfacings or seamless flooring, and polyurethane coatings related to seamless flooring. It also covers all serviceability requirements except those relating to flammability, fire safety and acoustical properties.

Physical and material requirements in Federal specifications for floor coverings are considered in separate sections. Military specifications for monolithic surfacings and Federal specifications for floor coverings and polyurethane coatings are summarized in comprehensive tables. Under each physical requirement, comments indicate whether it is a quality control or a performance requirement. Each comment is followed by a list of those Federal specifications which include the requirement and a brief description of the criteria and test methods in the specifications. Comments on materials requirements relate to their adequacy and applicability to the product for which they were written. Finally, recommendations are made for improvements in performance requirements which should be considered for inclusion in future flooring and floor covering specifications.

**TN823. Cryogenic Physics Section, summary of activities 1973, R. J. Soulen, Jr., Ed., Nat. Bur. Stand. (U.S.), Tech. Note 823, 23 pages (Mar. 1974) SD Catalog No. C13.46:823.**

Key words: Josephson junctions; noise thermometer; nuclear orientation; paramagnetism; superconductivity; temperature.

This report summarizes the research activities of the Cryogenic Physics Section which specifically relate to thermometry. The topics range from superconductive fixed points to nuclear orientation thermometry, as well as Josephson junction noise thermometry and paramagnetism.

**TN824. A laboratory study of some performance characteristics of an aluminum oxide humidity sensor, S. Hasegawa, L. Greenspan, J. W. Little, and A. Wexler, Nat. Bur. Stand. (U.S.), Tech. Note 824, 28 pages (Mar. 1974) SD Catalog No. C13.46:824.**

Key words: aluminum oxide sensor; humidity; humidity sensor; hygrometer; measurement of frost points; moisture measurement; water vapor measurement.

A laboratory study was made of the performance of aluminum oxide humidity sensors over a range of ambient temperatures from +20 °C to -60 °C encompassing dew points from +18 °C to frost points of -100 °C. Information was obtained on such characteristics as sensitivity, hysteresis, temperature effect, pressure-altitude effect and short-term and long-term repeatability. The sensors were found to be capable of detecting frost points as low as -100 °C at ambient temperatures of -40 °C and -



60 °C. It is estimated that the total uncertainty inherent in these sensors is approximately 4 °C.

**TN825. Properties of selected superconductive materials—1974 supplement**, B. W. Roberts, Nat. Bur. Stand. (U.S.), Tech. Note 825, 1974 Supplement, 88 pages (Apr. 1974) SD Catalog No. C13.46:825.

Key words: bibliography; composition; critical fields; critical temperature; crystallographic data; data compilation; low temperature; superconductive materials; superconductivity.

This report includes data on additional superconductive materials extracted from a portion of the world literature up to mid-1973. The data presented are new values and have not been selected or compared to values (except for selected values of the elements) previously assembled by the Superconductive Materials Data Center. The properties included are composition, critical temperature, critical magnetic field, crystal structure and the results of negative experiments. Special tabulations of high magnetic field materials with Type II behavior and materials with organic components are included. All entries are keyed to the literature and a list of reviews centered on superconductive materials is included. Extends NBS Technical Note 724.

**TN826. Cost-benefit analysis of computer graphics systems**, I. W. Cotton, Nat. Bur. Stand. (U.S.), Tech. Note 826, 47 pages (Apr. 1974) SD Catalog No. C13.46:826.

Key words: computer graphics; cost-benefit analysis; cost-effectiveness; economics; performance evaluation.

This report assesses the state-of-the-art in cost benefit analyses of computer graphics systems and suggests an approach for developing improved methodology. Cost-benefit analyses are distinguished from analyses of system performance in that the latter are directed at optimizing system performance at a given level of investment, while the former are directed at justifying the investment itself.

Computer graphic system design alternatives are first outlined. Then methods of analyzing the performance and costs of computer systems in general and graphic systems in particular are discussed. With this information it is shown how cost-effectiveness analyses may be performed. The next crucial step is to conduct benefit analysis, an ill-defined art. The results of benefit analysis must be combined with cost-effectiveness analysis in order to perform the desired cost-benefit analysis.

An experimental methodology is suggested for better performing benefit analyses of computer graphic systems. A more rigorous formulation of the cost-benefit procedure is then outlined. No attempt is made in this report to actually perform such an analysis.

**TN827. Controlled accessibility workshop report. A report of the NBS/ACM Workshop on Controlled Accessibility, Rancho Santa Fe, Calif., Dec. 10-13, 1972**, S. K. Reed and D. K. Branstad, Eds., Nat. Bur. Stand. (U.S.), Tech. Note 827, 86 pages (May 1974) SD Catalog No. C13.46:827.

Key words: access control; computer security; controlled accessibility; EDP management control; identification; measurement; security audit.

A report has been prepared of the NBS/ACM Workshop on Controlled Accessibility, December 1972, Rancho Santa Fe, Calif. The Workshop was divided into five separate working groups: access controls audit, EDP management controls, identification, and measurements. The report contains the introductory remarks outlining the purpose and goals of the Workshop, summaries of the discussions that took place in the working groups and the conclusions that were reached. A list of participants is included.

**TN828. Measures for air quality (1972-1973). Annual report-FY 1973**, J. R. McNesby, Nat. Bur. Stand. (U.S.), Tech. Note 828, 143 pages (May 1974) SD Catalog No. C13.46:828.

Key words: air pollution; measurement; standard reference material; water pollution.

This report is a project-by-project description of the Measures for Air Quality program covering the fiscal years 1972 and 1973. Participation in the program is bureau-wide but the program office operates out of the Institute for Materials Research. Although air pollution measurement science has formed the major thrust of the program, it has been extended in FY 73 to include the beginnings of a water pollution effort to respond to new needs, particularly those arising out of the requirements of the Federal Water Pollution Control Act of 1972. A report on the MAQ program for FY 72 was not issued. However, the project reports in the current document include progress made during FY 72 for those FY 73 projects which were active in FY 72. Where a project was terminated at the end of FY 72 its description is included in the present document with appropriate notation.

In water pollution the situation is much more complex since there are many more pollutants in more types of water that will be subject to control under the Federal Water Pollution Control of 1972. When a pollutant is of concern in the discharge permit program, water quality standards, the toxic pollutant list and in the specimen bank program, the state of the measurement art is scrutinized at NBS and the need for development assessed.

**TN829. Multicommodity network plotting via program NETPLT**, Z. G. Ruthberg, G. R. Bolotsky, and W. Slater, Jr., Nat. Bur. Stand. (U.S.), Tech. Note 829, 67 pages (June 1974) SD Catalog No. C13.46:829.

Key words: communication network; multicommodity network; network; network display; plotting algorithm; plotting program.

In the design and operation of complex networks, it is often an advantage to obtain a visual representation that readily allows for a quick appraisal of the network's current configuration or of its changed appearance due to variations of its nodes and links. The program NETPLT enables a user to plot the two leading characteristics of any multicommodity network: (1) nodes and links and (2) the multiple source-sink structure (multi-commodity property). The unique feature of NETPLT is its unambiguous planar representation of links. NETPLT uses an arc of a circle instead of the usual straight line, to represent a connector between a node pair (link).

**TN830. NBS cryogenic thermometry and the proposed cryogenic extension of the IPTS**, G. Cataland, R. P. Hudson, B. W. Mangum, H. Marshak, H. H. Plumb, J. F. Schooley, R. J. Soulen, Jr., and D. B. Utton, Nat. Bur. Stand. (U.S.), Tech. Note 830, 32 pages (May 1974) SD Catalog No. C13.46:830.

Key words: acoustical thermometry;  $\gamma$ -ray anisotropy thermometry; noise thermometry; nuclear magnetic resonance; nuclear quadrupole resonance; paramagnetism; superconductivity; temperature.

This article outlines a comprehensive and long-term program being carried out by NBS scientists of the Cryogenic Physics and Temperature Sections. The goals of the program are the extension of IPTS 68 below 13.81 K and the development of devices which make practical realizations of that scale convenient and reliable. We propose to contribute to international adoption of a thermodynamically accurate scale below 13.81 K by analyzing the results of three thermometers: the NBS Acoustical Thermometer (already in operation for several years), noise thermometry using the Josephson effect (recently



developed), and  $\gamma$ -ray anisotropy thermometry (recently studied in detail at NBS). Such a temperature scale will most likely be disseminated by the use of certain superconductors as thermometric reference points. Practical interpolation devices will be based on the principles of nuclear and electronic paramagnetism, nuclear quadrupole resonance, and nuclear magnetic resonance. Details of operation, measurement schemes and experimental progress made to date are included in nine appendices.

**TN831. Introduction to liquid flow metering and calibration of liquid flowmeters**, L. O. Olsen, Nat. Bur. Stand. (U.S.), Tech. Note 831, 60 pages (June 1974) SD Catalog No. C13.46:831.

Key words: calibration; liquid flow; liquid flowmeters; metering.

These notes are intended to serve as an instruction manual for technicians and engineers engaged in metering liquids and calibrating liquid flowmeters. It is a condensed review of the properties of liquids and the mathematical relations required in this work. References to more complete sources of properties of liquids, theoretical relations and instructions for metering liquids are included. Separate chapters discuss liquids and their properties as they affect flow, the theory of incompressible flow of liquids and the measurements required in the metering of liquids. One chapter describes several different apparatus and their use in the calibration of liquid flowmeters. The last chapter contains brief descriptions of the many types of flowmeters such as differential pressure, positive displacement, electromagnetic and ultrasonic. It also includes a discussion of the physical principles involved in their design and use.

**TN832. Report on planning session on software engineering handbook**, S. L. Stewart, Ed., Nat. Bur. Stand. (U.S.), Tech. Note 832, 18 pages (Nov. 1974) SD Catalog No. C13.46:832.

Key words: programming; quality software; software engineering.

This report from a planning committee sponsored by the National Bureau of Standards, the National Science Foundation, and the Association for Computing Machinery discusses the need for, coverage of, and audience for a proposed Software Engineering Handbook.

**TN833. Fire department ground ladders—results of a preliminary study**, H. P. Utech, Nat. Bur. Stand. (U.S.), Tech. Note 833, 82 pages (July 1974) SD Catalog No. C13.46:833.

Key words: aluminum; fire department; ladders; performance requirements; standards.

The key performance requirements for fire department ground ladders were determined. Existing ladder standards were reviewed and found to be unnecessarily restrictive in some areas and inadequate and unrealistic in others. Included in the report are metallurgical studies of three ladders that failed in service as well as a correlation of hardness with tensile and yield strength for 6061-T6 alloy.

**TN834. Information handling needs within the U.S. Patent Office**, S. Jeffery, Nat. Bur. Stand. (U.S.), Tech. Note 834, 17 pages (June 1974) SD Catalog No. C13.46:834.

Key words: administrative operations; data handling; data storage and retrieval; information handling technology; information processing; intellectual process; patent examination; Patent Office; patent storage; production statistics.

This paper examines aspects of the Patent Office's needs that make it different from other existing information retrieval systems. The paper then reviews current technology and assesses its ability to provide effective and economical tools to aid the Patent Office.

**TN835. Tabulation of published data on electron devices of the U.S.S.R. through December 1973**, C. P. Marsden, Nat. Bur. Stand. (U.S.), Tech. Note 835, 130 pages (Nov. 1974) SD Catalog No. C13.46:835.

Key words: electron devices; electron tubes; semiconductors; U.S.S.R.

This tabulation includes data on U.S.S.R. electron devices as collected from publications, mostly handbooks, published by the various ministries and institutes of the U.S.S.R. Information is given on all active devices ranging from receiving to microwave devices, semiconductor devices, and miscellaneous devices such as photographic flash tubes and thermistors. Supersedes NBS TN715.

**TN836. Detector actuated automatic sprinkler systems—a preliminary evaluation**, R. L. P. Custer, Nat. Bur. Stand. (U.S.), Tech. Note 836, 27 pages (July 1974) SD Catalog No. C13.46:836.

Key words: bedding fires; design criteria; detector actuated automatic sprinklers; detectors; levels of protection; life safety; sprinklers.

An investigation was conducted to evaluate the capabilities of a detector actuated automatic sprinkler system to protect individuals who are intimately associated with the first materials ignited such as bedding materials. Tests were conducted in a simulated nursing home bedroom. System response was evaluated for both smoldering and open flaming ignition sources. It was determined that barring electrical or mechanical failure the system could be nearly 100 percent effective with smoldering fires. The effectiveness with open flaming fires was difficult to evaluate. Although these fires were extinguished with minimum damage in times as short as 36 seconds the possible effects of flammable blankets and sleepwear were not tested. It was estimated that perhaps one third of the potential victims of open flaming fires might be saved. Although these tests were limited in scope, some tentative design criteria for detector actuated sprinkler systems are presented and possible alternatives offered.

**TN837. Barrier penetration tests**, R. T. Moore, Nat. Bur. Stand. (U.S.), Tech. Note 837, 191 pages (June 1974) SD Catalog No. C13.46:837.

Key words: barrier penetration; intrusion detection; intrusion resistance; physical security.

Sixteen structural barrier panels were tested to determine their resistance to forcible penetration through the use of readily available tooling. Thirteen of these represented experimental techniques to reinforce an existing structural barrier of low penetration resistance; the other three were designs which would be most appropriate to consider as replacement barriers. Minimum man-passable sized openings were made in the barriers in working times which averaged 7.85 minutes and ranged from 1.52 to 25.56 minutes. One of the replacement and two of the reinforcing designs showed superior cost-effectiveness.

Seven woven, wire-mesh security fence specimens were also tested for their intrusion deterrence capability. The test results indicate that the deterrent influence of unelectrified fences of the type tested is largely psychological rather than physical. All of the specimens could be penetrated in 0.14 minutes or less.

Samples of the acoustical and vibrational data produced during the penetration tests add to the growing body of data which are expected to be useful in the design and selection of electronic intrusion alarm equipments.

**TN838. The use of weather and climatological data in evaluating the durability of building components and materials**, L. W.



Masters and W. C. Wolfe, Nat. Bur. Stand. (U.S.), Tech. Note 838, 101 pages (Aug. 1974) SD Catalog No. C13.46:838.

Key words: accelerated aging; building components and materials; climatological data; durability; environmental factors; long-term tests; short-term tests; weathering factors.

The durability of building components and materials is dependent, to a large extent, on the in-service environment to which they are subjected in service. Thus, the prediction of durability requires knowledge of the service environment.

Weathering factors, which comprise one group of environmental factors, are the subject of this report. The objectives of this report are to indicate how, in the present state of knowledge, weather and climate data can be used to aid in quantifying weathering factors so that durability tests for building components and materials may be designed.

**TN839. Fire detection: The state-of-the-art**, R. L. P. Custer and R. G. Bright, Nat. Bur. Stand. (U.S.), Tech. Note 839, 119 pages (June 1974) SD Catalog No. C13.46:839.

Key words: fire detection; fire detection code requirements; fire detector testing and standards; fire detectors; fire signatures.

The current state-of-the-art in fire detection technology is reviewed considering the nature of fire signatures, detection modes used, test methods, performance requirements and code requirements for fire detection. Present trends in standards development and recommendations for future work are included. An extensive bibliography is provided.

**TN840. Reference materials for collaborative tests of air quality methods**, R. H. Johns and J. K. Taylor, Nat. Bur. Stand. (U.S.), Tech. Note 840, 17 pages (Aug. 1974) SD Catalog No. C13.46:840.

Key words: air pollution; chemical analysis; Standard Reference Materials.

Reference materials and associated distribution apparatus were developed for seven ambient air contaminants and for two smokestack contaminants. These established the reference base for collaborative tests of ASTM procedures for ambient air quality and smokestack emissions carried out under a three-year program known as Project Threshold.

**TN841. Review of reverberant sound power measurement standard and recommendations for further research**, Nat. Bur. Stand. (U.S.), Tech. Note 841, 24 pages (Aug. 1974) SD Catalog No. C13.46:841.

Key words: acoustics; noise; reverberation room; sound power; statistical room acoustics.

This report presents a critical review of American National Standard S1.21-1972, "Methods for the Determination of Sound Power Levels of Small Sources in Reverberation Rooms." This standard, as now embodied, represents a major advance in the state-of-the-art of reverberation room measurement of sound power. This report was prepared in order to identify additional analytical and experimental information needed for further refinement of this standard. This report presents a detailed critique of specific items in the standard. Indications are given of both general research areas for statistical room acoustics and of specific research areas for improved reverberant room sound power measurements.

**TN842. Concepts in quality software design**, S. L. Stewart, Ed., Nat. Bur. Stand. (U.S.), Tech. Note 842, 89 pages (Aug. 1974) SD Catalog No. C13.46:842.

Key words: control structures; GOTO-less programming; program validation; programming; proofs of correctness; referential transparency; software quality; structured programming; top-down programming.

A seminar series on quality software, sponsored by the Systems and Software Division, was held at the National Bureau of Standards during the summer of 1972. This Note includes five of these seminars in edited form. (I) A brief background provides motivation for studies in software quality. The authors mention some factors which influence software manufacture, and propose measures which might quantify concepts of "software quality." Several approaches to establishing program correctness receive attention. (II) Elements of top-down programming are sketched out and then examined in detail. An extended critique of another top-down experiment provides example material. (III) Powers of various structured control constructs are compared within a framework of weak and strong program equivalence. Results include a demonstration that Dijkstra's D-programs are strongly equivalent to programs built from functions and one-input/two-output predicates. (IV) After a review of Quine's notion of referential transparency, the author examines elements of good and bad programming practice. In addition, a table of programming proverbs provides guidance to a programmer, and should be especially useful to a novice. (V) Discussions on problem and program specification provide an introduction to a review of proof-of-correctness techniques. Then, noting some practical limitations on proving correctness, the author goes on to examine selected facets of program synthesis.

**TN843. A technical guide to computer-communications interface standards**, A. J. Neumann, B. G. Lucas, J. C. Walker, and D. W. Fife, Nat. Bur. Stand. (U.S.), Tech. Note 843, 111 pages (Aug. 1974) SD Catalog No. C13.46:843.

Key words: ADP standards; communications disciplines; computer networks; data communications.

A technical summary and guide is given for existing and forthcoming Federal and National standards on data communications pertinent to computer networking. Selected international standards and industry practices are included for completeness. Prepared to assist the application of standards within the World Wide Military Command and Control System, this handbook should be useful to all ADP system designers interested in uniform data terminal interfaces, character sets and codes, keyboard arrangements, and communications line disciplines for effective message exchange between computers.

**TN844. Designs for the calibration of small groups of standards in the presence of drift**, J. M. Cameron and G. E. Hailes, Nat. Bur. Stand. (U.S.), Tech. Note 844, 35 pages (Aug. 1974) SD Catalog No. C13.46:844.

Key words: calibration; calibration design; experiment design; instrumental drift; measurement process; statistical analysis; trend elimination.

The process of calibrating a small number of "unknown" standards relative to one or two reference standards involved determining differences among the group of objects. Drift, due most often to temperature effects, or a "left-right" polarity effect can bias both the values assigned to the objects and the estimate of the effect of random errors. This note presents schedules of measurements of differences that eliminate the bias from these sources in the assigned value and variances at the same time gives estimates of the magnitude of these extraneous components. The use of these designs in measurement process control is discussed and a computer program in BASIC is presented.

**TN845. Cost analysis for computer communications**, R. P. Blanc, Nat. Bur. Stand. (U.S.), Tech. Note 845, 40 pages (Sept. 1974) SD Catalog No. C13.46:845.



Key words: computer networking; cost study; interactive terminals; value-added networks.

This report summarizes a communication cost study relevant to the needs of the NSF Networking for Science Program. The primary purpose of this report is to provide an approximation to the communications costs of connecting a specified number of host computers in selected locations with a specified number of interactive user terminals. Cost factors from existing, proposed, and modeled value-added networks are applied to hypothetical traffic demands to arrive at cost estimates.

**TN847. Dataplot 70: Fortran-callable plotting routines,** C. V. Young and P. G. Stein, Nat. Bur. Stand. (U.S.), Tech. Note 847, 32 pages (Oct. 1974) SD Catalog No. C13.46:847.

Key words: digital plotter; graph; graphics; minicomputer; plotter.

A description is given of Dataplot 70, a program which enables plotting 1) lines between pairs of X-Y coordinates and 2) a string of ASCII characters at a given X-Y coordinate on the electrostatic printer/plotter. Detailed instructions are provided enabling the user to 1) convert data to plotter format, 2) draw axis, 3) label axis, 4) scale data, 5) handle arrays, 6) produce symbols at end points, and 7) offset the origin. Hardware and software requirements as well as loading and operating instructions are given.

A sample FORTRAN calling program is included and each instruction is explained in detail. The output of the calling program is shown. Error messages produced by Dataplot 70 are explained.

**TN848. A bibliography of the Russian reference data holdings of the library of the Office of Standard Reference Data,** G. B. Sherwood and H. J. White, Jr., Nat. Bur. Stand. (U.S.), Tech. Note 848, 20 pages (Sept. 1974) SD Catalog No. C13.46:848.

Key words: bibliography; reference data; Russian literature.

This text presents a listing of the Russian reference data holdings of the library of the Office of Standard Reference Data of the National Bureau of Standards as of March 1974. In addition to the bibliographic listing, information on the status of translations into English is given where available.

**TN849. A FORTRAN analyzer,** G. Lyon and R. B. Stillman, Nat. Bur. Stand. (U.S.), Tech. Note 849, 28 pages (Oct. 1974) SD Catalog No. C13.46:849.

Key words: computation and flow analysis; FORTRAN language use; programming aids; syntax analysis.

Details of a FORTRAN analysis package are presented. Examples illustrate a current operational level which gathers FORTRAN statement and frequency-of-execution statistics. Arguments support a simple technique for monitoring FORTRAN executions.

**TN851. Computer system capacity fundamentals,** D. J. Kuck, Nat. Bur. Stand. (U.S.), Tech. Note 851, 25 pages (Oct. 1974) SD Catalog No. C13.46:851.

Key words: capacity; computer; evaluation; measurement; performance.

A framework for the study of computer capacity is given by means of a definition of capacity in terms of speeds of various parts of a computer as well as memory size. The calculation of theoretical capacity is given for several combinations of processor, memory, and I/O bandwidth for both overlapped and nonoverlapped machines. The tradeoff between primary memory size and I/O bandwidth is discussed in terms of the new definition.

**TN852. A study of wind pressures on a single-family dwelling in model and full scale,** R. D. Marshall, Nat. Bur. Stand. (U.S.), Tech. Note 852, 40 pages (Oct. 1974) SD Catalog No. C13.46:852.

Key words: aerodynamics; boundary layers; buildings; codes and standards; wind loads; wind tunnels.

Wind pressures measured on a single-family dwelling are compared with results obtained from a 1:80 scale model placed in a turbulent boundary layer. It is shown that the fluctuating components of surface pressures far exceed the mean or steady pressures and are well correlated over sizeable roof areas. The consistently low fluctuating pressure coefficients obtained from the wind tunnel model are attributed to improper simulation of the lower portion of the atmospheric boundary layer. Comparisons between actual loads and specified design loads suggest that certain current provisions are marginal for tributary areas and excessive for localized areas such as ridges, eaves and corners. A procedure for expressing loads on both localized and extended roof areas in terms of mean pressure coefficients and a peak factor is described.

**TN853. State building regulatory programs for mobile homes and manufactured buildings—a summary,** P. W. Cooke, H. K. Tejuja, R. D. Dikkers, and L. P. Zelenka, Nat. Bur. Stand. (U.S.), Tech. Note 853, 35 pages (Sept. 1974) SD Catalog No. C13.46:853.

Key words: building regulation; enforcement; evaluation; inspection; legislation; manufactured building; mobile homes; rules and regulations; state-of-the-art study.

Information describing State mobile home and manufactured building regulatory programs are presented in two series of summary tables. The tables provide information on salient elements of the enabling legislation and the administrative rules and regulations promulgated for each State program. Other features of the various enforcement programs, including the status of reciprocity for the interstate acceptance of mobile homes and manufactured buildings are also enumerated.

### 3.14. CONSUMER INFORMATION SERIES

Practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge

for shopping in today's technological marketplace.

No publications issued in this series during this period.



### 3.15. NBS INTERAGENCY REPORTS

A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution by the National Technical Information Service (NTIS), Springfield, Va. 22151, in paper copy or microfiche form. This series MUST be ordered from NTIS by the "COM, PB, or AD" number listed at the end of each entry.

**NBSIR 73-108. City games—City I operator's manual, J. E. Moriarty, 24 pages (Oct. 1973). Order from NTIS as COM 74-10701-2.**

**Key words:** city; computer; directors; economic; games; government; metropolitan; players; sectors; simulation; social; urban.

City I is an operational simulation game in which participants make economic, government, and social decisions affecting a hypothetical metropolitan area. The game is run on an IBM 1131 Central Processor with at least 8K and single disc storage.

This manual describes the methods of operating the Central Processor relative to the game along with the special coding required to change and/or update the computer program and core mapping.

It is assumed throughout this manual that the operator knows how to cold start the 1130, change carriage tapes, and load and clear the card reader.

**NBSIR 73-109. City games—City I director's manual, J. E. Moriarty, 76 pages (Sept. 1973). Order from NTIS as COM 74-10701-1.**

**Key words:** city; computer; director's; economic; games; government; metropolitan players; sectors; simulation; social urban.

City I is an operational simulation game in which participants make economic and government decisions affecting a hypothetical metropolitan area. Through the use of a computer, the simulated urban system responds to the participant's as any real city would. The City I Director instructs the players in procedure and coordinates the overall game play. This manual describes the details of administering the game from the Director's point of view and presents examples of decision codes, formats, and general information necessary to direct the game.

**NBSIR 73-110. City games—City I player's manual, J. E. Moriarty, Ed., 150 pages (Mar. 1973). Order from NTIS as COM 73-11191.**

**Key words:** city; computer; directors; economic; games; government; metropolitan; players; sectors; simulation; social; urban.

City I is an operational simulation game in which participants make economic, government, and social decisions affecting a hypothetical metropolitan area. Through the use of a computer, the simulated urban system responds to the participant's decisions as any real city would. Each player in City I is assigned to a team which shares an economic and governmental role. This manual describes the player details for the economic and government sectors along with general information required for game play. It is one of three manuals necessary for game play. (Player's Manual, Director's Manual, Computer Operator's Manual). Each of these manuals are designed to be used for reference and by themselves will not describe enough details for

a complete game play. The game is run on an IBM 1130 computer with 8K core and single disc.

**NBSIR 73-112. City games—City 4 computer operator's manual, J. E. Moriarty, 56 pages (Sept. 1973). Order from NTIS as COM 74-10702-3.**

**Key words:** City IV; computer; Fortran; gaming; IBM 360/70; JCL; simulation.

This manual is written for an IBM 360/70 computer. It describes the necessary Fortran & JCL commands required for computer operation of the CITY IV game. Test commands and sequences are presented along with complete computer operating instructions for the Game. It is expected that this manual, along with a Game Director's manual will provide complete instructions for the operation of CITY IV.

**NBSIR 73-113. City games—City 4 director's manual, J. E. Moriarty, Ed., 286 pages (Mar. 1974). Order from NTIS as COM 74-10702-1.**

**Key words:** city; computer; director's; economic; games; government; metropolitan players; sectors; simulation; social; urban.

City 4 is an operational simulation game in which participants make economic and government decisions affecting a hypothetical metropolitan area. Through the use of a computer, the simulated urban system responds to the participant's as any real city would. The City 4 Director instructs the players in procedure and coordinates the overall game play. This manual describes the details of administering the game from the Director's point of view and presents examples of decision codes, formats, and general information necessary to direct the game.

**NBSIR 73-114. City games—City 4 player's manual, J. E. Moriarty, Ed., 276 pages (Feb. 1974). Order from NTIS as COM 74-10702-2.**

**Key words:** city; computer; directors; economic; games; government; metropolitan; players; sectors; simulation; social; urban.

City 4 is an operational simulation game in which participants make economic, government, and social decisions affecting a hypothetical metropolitan area. Through the use of a computer, the simulated urban system responds to the participant's decisions as any real city would. Each player in City 4 is assigned to a team which shares an economic and governmental role. This manual describes the player details for the economic and government sectors along with general information required for game play. It is one of three manuals necessary for game play. (Player's Manual, Director's Manual, Computer Operator's Manual). Each of these manuals are designed to be used for reference and by themselves will not describe enough details for a complete game play. The game is run on an IBM O.S./360 computer.

**NBSIR 73-152. Measurement of transit time and related transistor characteristics, D. E. Sawyer, G. J. Rogers, and L. E. Huntley, 131 pages (Oct. 1973). Order from NTIS as AD 914258.**

**Key words:** delay time; electronics; high-frequency probes; Sandia bridge; scattering; S-parameters; transistors; vector voltmeter.

Two instruments for transistor delay-time measurements, the



vector voltmeter and Sandia bridge, were analyzed and comparative measurements were made on several types of commercial and two special transistors. It was found that extraneous pickup at the measurement frequency can cause large errors in measured delay time. A technique for minimizing these errors was developed and verified for the Sandia bridge by removing the frequency dependence of delay force, probe tip protrusion and lateral motion (skating) with loading were recorded for special probe assemblies to be used in an automatic wafer prober for measurements on transistors in custom-designed integrated circuit wafers. The data is used to assist in adjusting the probers. A technique was developed for determining the effects of the probe assemblies on transistor measurements made from 0.1 to 2.0 GHz. Each probe assembly may be represented by an equivalent circuit consisting of three unknowns; these unknowns are determined by making impedance measurements at the input connectors with the probe tips contacted by combinations of open circuits, short circuits, and resistors of known value. Arrays of such terminations were successfully fabricated and characterized. An S-parameter interlaboratory testing program was developed. The plan calls for six of each of three types of transistors to be measured by participants at frequencies from 0.11 to 2.0 GHz. Additionally, a 10-dB attenuator and R-C networks on TO-72 headers are to be circulated to pinpoint measurement discrepancies.

**NBSIR 73-180. Testing of the NBS clinical microcalorimeter, E. J. Prosen and R. N. Goldberg, 31 pages (Apr. 1973). Order from NTIS as COM 74-10139.**

Key words: clinical chemistry; clinical microcalorimetry; microcalorimeter; NBS microcalorimetry; testing of microcalorimeter.

The NBS Clinical Microcalorimeter has been tested for stability, sensitivity, ease of operation, and accuracy. The accuracy was tested by means of electrical calibration and the determination of the heat of neutralization of HCl(aq) with NaOH(aq). The heat of this reaction agrees with the best literature value within the precision of the calorimeter. The precision is about 0.6 percent when measuring about 50 mJ of heat of chemical reaction. The accuracy is estimated as 1 percent. The precision of electrical energy determination is about 0.4 percent for energies of from 1 to 1400 mJ.

**NBSIR 73-199. Experimental and analytical studies of floor covering flammability with a model corridor, W. Denyes and J. Quintiere, 115 pages (May 1973). Order from NTIS as COM 74-10129.**

Key words: flame spread; floor covering materials; model corridor; scaling laws; test method.

An experimental model corridor facility was designed, constructed, and instrumented. The facility examines flame spread over floor covering materials in a small scale corridor under a forced air flow condition. A gas burner flame serves as the ignition source.

A study was made of the factors influencing flame spread in the model corridor. These factors included energy release rate of the ignition source, air velocity, and model corridor geometry. Twenty-six carpet materials and 5 other floor covering materials were studied in the model corridor, and 369 flame spread runs were conducted.

It was found that flame spread behavior in the model corridor generally involves either a rapidly accelerating flame front which propagates the full 8 foot length of the test section ("flameover"), or involves a decelerating flame front which results in extinction a short distance from the ignition source. Radiant heating of the floor material due to hot products of combustion heating the ceiling is a significant factor in causing flameover. Carpet assembly

was found to affect flame spread more significantly than pile fiber type.

The data have been analyzed to determine quantitatively the effects of the factors influencing flame spread. Scaling relationships have been presented to attempt to extrapolate the model corridor results to full scale corridor fires.

Finally a procedure has been suggested for using the facility in a floor covering flammability test method. The procedure is based on determining the minimum energy input rate to cause flameover.

**NBSIR 73-200. A model corridor for the study of the flammability of floor coverings, W. Denyes and J. W. Raines, 40 pages (May 1973). Order from NTIS as COM 74-10478.**

Key words: air flow; energy input; flameover; flame spread; floor covering flammability; model corridor; test repeatability.

A program was carried out to develop a laboratory test method that would measure the flame propagation characteristics of floor covering materials. A facility was designed which included a floor mounted specimen in a rectangular cross-sectional duct having a forced supply of air and a gas burner ignition source. The effects of variations in duct size, ignition source, and air flow were studied. Factors influencing repeatable test results were explored. Flame spread was measured by an observer and temperature and heat flux measurements were recorded on an electronic digital data acquisition system.

**NBSIR 73-202. Conservation via effective use of energy at the point of consumption, C. A. Berg, 37 pages (Apr. 1973). Order from NTIS as COM 74-10479.**

Key words: buildings; energy conservation; industrial equipment.

The practices and equipment employed at the point of energy consumption in buildings and in industrial processes permit excessive consumption of energy. It is estimated that if full application of the economically justifiable technical improvements presently available were made to equipment and practices in buildings and industry, as much as 25 percent of the total primary fuel consumption in the U.S.A. could be conserved. The reasons why economically justifiable application of effective technology at the point of energy consumption has not been widely adopted in the past are considered. The needs to facilitate adoption of effective equipment and practices in the future are discussed.

**NBSIR 73-210. LEAA police equipment survey of 1972. Volume I: The need for standards—priorities for police equipment, R. Ku, E. Bunten, and P. Klaus, 212 pages (July 1973). Order from NTIS as COM 74-11767.**

Key words: police; police equipment; standards.

The report describes the methodology of and summarizes a portion of the data from the LEAA Police Equipment Survey of 1972. One of a series of seven reports resulting from this nationwide mail survey of a stratified random sample of 1386 police departments, the present report summarizes the answers of 1100 police departments concerning the need for performance standards for items of law enforcement used in their departments. Each sample department was asked to rank one list of equipment categories and nine lists of equipment items within those categories in terms of the need for standards for those equipment within their own departments. The data are presented by all responding departments, by all city departments, by seven department types, and by ten LEAA geographical regions. Data describing the characteristics of the responding departments are also presented.



**NBSIR 73-211. LEAA police equipment survey of 1972. Volume II: Communications equipment and supplies**, S. Mumford, P. Klaus, E. Buntin, and R. Cunitz, 175 pages (Final July 1971-July 1973). Order from NTIS as COM 74-10950.

Key words: communications; mobile radio; police; police equipment; portable radio; standards.

The report outlines the methodology of and summarizes a portion of the data from the LEAA Police Equipment Survey of 1972. One of a series of seven reports resulting from this nationwide mail survey of a stratified random sample of police departments, the present report summarizes the answers of 428 police departments concerning their communications equipment and supplies: use of mobile radios and portable radios; power supplies for portable radios; scramblers; portable/mobile radios; helmets with built-in communications; needs for standards and problems associated with communications equipment and supplies. The data are presented by all responding departments and by seven department types.

**NBSIR 73-212. LEAA police equipment survey of 1972. Volume III: Sirens and emergency warning lights**, P. Klaus and E. Buntin, 141 pages (July 1971-Sept. 1973). Order from NTIS as COM 74-11009.

Key words: emergency warning lights; police equipment; sirens; standards.

The report outlines the methodology of and summarizes a portion of the data from the LEAA Police Equipment Survey of 1972. One of a series of seven reports resulting from this nationwide mail survey of a stratified random sample of police departments, the present report summarizes the answers of 437 police departments concerning their sirens and emergency warning lights: use of sirens and lights; experience with most commonly used electronic sirens, electromechanical sirens, and emergency warning lights; purchasing, repair and replacement of this equipment; and training of officers in use of this equipment. The data are presented by all responding departments and by seven department types.

**NBSIR 73-213. LEAA police equipment survey of 1972. Volume IV: Alarms, security equipment, surveillance equipment**, J. L. Eldreth, E. D. Buntin, and P. A. Klaus, 147 pages (July 1971-Oct. 1973). Order from NTIS as COM 74-11771.

Key words: alarm systems; cameras; police; police equipment; security equipment; surveillance equipment.

The report outlines the methodology of and summarizes a portion of the data from the LEAA Police Equipment Survey of 1972. One of a series of seven reports resulting from this nationwide mail survey of a stratified random sample of police departments, the present report summarizes the answers of 447 police departments concerning their use of alarm systems, cameras, security equipment, and surveillance equipment: purchasing practices, typical patterns of use, and needs for standards for such equipment. The data are presented by all responding departments and by seven department types.

**NBSIR 73-214. LEAA police equipment survey of 1972. Volume V: Handguns and handgun ammunition**, S. Bergsman, E. Buntin, and P. Klaus, 102 pages (July 1971-Aug. 1973). Order from NTIS as COM 74-11239.

Key words: ammunition; handguns; police; police equipment; standards.

The report outlines the methodology of and summarizes a portion of the data from the LEAA Police Equipment Survey of 1972. One of a series of seven reports resulting from this nationwide mail survey of a stratified random sample of police departments, the present report summarizes the answers of 445 police

departments concerning their officers' use of handguns and handgun ammunition: on-duty and off-duty use, types and calibers in use, and problems encountered. The data are presented by all responding departments and by seven department types.

**NBSIR 73-215. LEAA police equipment survey of 1972. Volume VI: Body armor and confiscated weapons**, G. B. Hare, P. A. Klaus, and E. D. Buntin, 104 pages (Oct. 1973). Order from NTIS as COM 74-11010.

Key words: ballistic protective equipment; body armor; confiscated weapons; police; standards.

The report outlines the methodology of and summarizes a portion of the data from the LEAA Police Equipment Survey of 1972. One of a series of seven reports resulting from this nationwide mail survey of a stratified random sample of police departments, the present report summarizes the answers of 440 police departments concerning body armor and confiscated weapons: preference for hidden or visible body armor; use of other ballistic protective equipment; routine operations where body armor would be most useful; current problems and failures with present equipment; needs for standards for the testing and assessment of penetration capabilities of body armor; disposition of confiscated weapons. The data are presented by all responding departments and by seven department types.

**NBSIR 73-216. LEAA police equipment survey of 1972. Volume VII: Patrolcars**, E. D. Buntin and P. A. Klaus, 115 pages (July 1973). Order from NTIS as COM 74-11011.

Key words: patrolcar; police; police vehicles; standards.

The report outlines the methodology of and summarizes a portion of the data from the LEAA Police Equipment Survey of 1972. One of a series of seven reports resulting from this nationwide mail survey of a stratified random sample of police departments, the present report summarizes the answers of 449 police departments concerning their patrolcars: purchasing practices; types of options and accessories usually selected; types of equipment stored in the patrolcar; typical patterns of use; and needs for standards for systems or aspects of patrolcars. The data are presented by all responding departments and by seven department types.

**NBSIR 73-233. Non-metallic antenna-support materials**, D. E. Marlowe, N. Halsey, R. A. Mitchell, and L. Mordfin, 53 pages (Apr. 1973). Order from NTIS as COM 74-11770.

Key words: Composite materials; end fittings for FRP rod; environmental resistance of GRP rod; fiber-reinforced-plastic rod; glass-reinforced-plastic rod; guys, antenna; mechanical properties of GRP rod; pultrusion; reinforced plastic rod; stress rupture of GRP rod.

A program was initiated to develop a non-conductive FRP rod material for use as guy lines and catenaries in large antenna systems. It is intended that the longterm structural properties of the new material, under adverse weathering conditions, be superior to those exhibited by the GRP rod and rope materials which are available at the present time. Two new end fittings for FRP rod were developed which out-perform commercially available fittings. These two fittings, which enable the tensile strengths of the rod materials to be accurately determined, include a shear-type fitting and a compression-type fitting. Deficiencies in the physical characteristics of existing GRP rod materials were identified, and modifications to the manufacturing processes were proposed to overcome these deficiencies. A sub-contract was let for the manufacture of experimental GRP rods using the modified processes. A bank of six high-capacity creep testing machines was designed and is being assembled. These machines, which will accomodate long specimen lengths, are



equipped with environmental chambers to permit stress-rupture testing under elevated temperature and saturated humidity conditions.

**NBSIR 73-234. Drapery and curtain fires—data element summary of case histories**, A. K. Vickers, 28 pages (July 1973). Order from NTIS as COM 74-10128.

Key words: burns; case histories; curtains; death; draperies; FFACTS; fires; flammable fabrics; houses; standards; statistical data.

A preliminary examination of 1,567 computerized case histories from the NBS Flammable Fabric Accident Case and Testing System has found 77 incidents in which curtains and draperies were involved in fires. This report is a summary of information relating to these 77 incidents, and includes the location of incidents, ignition sources, personal injury, fabrics involved and personal characteristics of victims. Fifteen people died from these fires and 32 others were injured. Curtains or draperies were the first fabric item to ignite in 28 of 55 curtain and drapery incidents in which the ignition source is known.

**NBSIR 73-246. Fire research publications, 1969-1972**, N. H. Jason, R. G. Katz, and P. A. Powell, 14 pages (July 1973). Order from NTIS as COM 74-10989.

Key words: bibliographies; construction materials; fire departments; Fire Research and Safety Act; fire tests; flammability tests; flammable fabrics; Flammable Fabrics Act; protective clothing.

A list of publications is provided representing the papers and journal articles prepared by Fire Technology Division and by Building Fires and Safety Section of the Center for Building Technology personnel and by external laboratories under contract to the Fire Technology Division from 1969 through 1972.

**NBSIR 73-254. A mercury vapor generation and dilution system**, E. P. Scheide, R. Alvarez, B. Greifer, E. E. Hughes, and J. K. Taylor, 12 pages (Oct. 1973). Order from NTIS as COM 74-10987.

Key words: atomic absorption; gas generation system; mercury; occupational safety.

This report describes a system capable of producing well-defined test atmospheres of mercury in air or other diluent gas at concentrations between 0.005 and 0.5  $\mu\text{g}/\text{l}$  and an analytical system for the analysis of these gas mixtures. Various parameters that affect the generator and analytical system and their interactions are discussed. This system provides a means of calibration of the various analytical systems for mercury now in use. The analytical unit of the system can also be used for the determination of mercury in industrial atmospheres by collecting the mercury on a silver wool collector, and then desorbing it by heat into a flameless atomic absorption spectrometer.

**NBSIR 73-280. Thermodynamics of chemical species important to rocket technology**, T. B. Douglas and C. W. Beckett, 109 pages (Jan. 1, 1973). Order from NTIS as COM 74-10549.

Key words: associated vapors; graphite; heat capacity; molybdenum; molybdenum pentafluoride; niobium; radiance temperature; spectral emittance; surface roughness; thermodynamic properties.

The enthalpy of high-purity molybdenum was accurately measured 273-1173 K, and joined smoothly to lower-temperature (German) and higher-temperature (NBS) results to give thermodynamic functions 273-2100 K. The heat capacity of a grade of Poco graphite was measured by a subsecond-duration pulse-heating technique 1500-3000 K (estimated inaccuracy, 3% or less). Based largely on earlier NBS IR and Raman spectroscopy, ideal-gas thermodynamic functions for  $\text{MoF}_5$  were generated and

are tabulated for 0-6000 K. Three alternative classical-thermodynamic or quasi-chemical treatments are developed for deriving thermodynamic properties from vaporization data on partially associated vapors, with calculations to illustrate experimental-error propagation for one treatment. A subsecond-duration pulse-heating technique was applied to niobium metal to measure its change in normal spectral emittance and radiance temperature at and near its melting point (wavelength, 650 nm), studying dependence on solid-state roughness (0.1 to 0.95  $\mu\text{m}$ ).

**NBSIR 73-281. Thermodynamics of chemical species important to rocket technology**, T. B. Douglas and C. W. Beckett, 122 pages (July 1, 1973). Order from NTIS as COM 74-10550.

Key words: electrical resistivity; iron; molybdenum pentafluoride; partly associated vapors; solid-state transformations; solution calorimetry; specific heat; spectral emittance; transition alloys; vapor pressure.

Using a subsecond-duration transient technique, the specific heat, electrical resistivity, and hemispherical total emittance were simultaneously measured 1500-2800 K for iron and the alloy 80Nb-10Ta-10W (estimated uncertainties: 3%, 0.5-1%, and 3% for the respective properties). Comparisons are made with generalized approximations. At the gamma-to-delta transformation of iron (about 1680 K), the temperature, heat of transformation, specific heat, spectral emittance, and electrical resistivity were measured, thereby demonstrating the feasibility of the technique for solid-solid transformations. Two other alloys were likewise measured. Solution calorimetry involving several thermochemical steps (including oxidation by  $\text{XeO}_3$  in aqueous HF) gave the standard heat of formation of  $\text{MoF}_5(\text{c})$ . A new static vapor-pressure method, after verification to 1 percent by  $\text{I}_2$  and  $\text{MoF}_6$ , and after modifications to deal with the necessarily added  $\text{MoF}_6$ , gave the vapor pressure of  $\text{MoF}_5$  at 393 K and indicated (using also earlier NBS transpiration data) 85-90 mole percent of monomer in the saturated vapor.

**NBSIR 73-287. Procedures for the calibration of volumetric test measures**, J. F. Houser, 24 pages (Aug. 1973). Order from NTIS as COM 73-11928/1GA.

Key words: air density; calibration; gravimetric; neck; volumetric.

The values for graduated neck type volumetric vessels may be obtained by either gravimetric or volumetric calibrations. This text describes the two methods of calibration and the data reduction associated with each method. Procedures for preparing these vessels for test are discussed. Also included are illustrations for data recording.

**NBSIR 73-290. Development of a dynamic pressure calibration technique. A progress report**, P. S. Lederer, 4 pages (Oct. 15, 1973). Order from NTIS as COM 74-10974.

Key words: dynamic calibration; pressure; transducer.

Plans are described for experimental investigation of a hydraulic sinusoidal pressure calibrator as a basis for development of dynamic pressure calibration techniques for frequencies up to 2000 Hz.

**NBSIR 73-294. Cost sharing as an incentive to attain the objectives of shoreline protection**, H. E. Marshall, 70 pages (Dec. 1973). Order from NTIS as COM 74-10541.

Key words: beach erosion control; cost sharing; economics; efficiency; equity; incentives; shoreline protection.

The nation's shorelines are being eroded by high winds and waves. Nonfederal interests have traditionally received Federal help in the form of cost sharing for protective structures. This study provides the Army Corps of Engineers with an evaluation of alternative cost-sharing rules for shoreline protection with



respect to efficiency, equity, and administrative feasibility.

Existing cost-sharing rules are described for hurricane, beach erosion, and emergency protection. The present cost-sharing system appears to induce local interests to choose (1) costly techniques of protection, e.g., engineering rather than management techniques, and (2) overbuilt projects in terms of the efficient scale.

It is concluded that the Association Rule, which requires local beneficiaries of shoreline protection to share in all of the costs of a project purpose in the proportion that local benefits bear to national benefits at the margin, should be applied to all shoreline protection programs. All techniques of protection should be subject to the same percentage cost-sharing rule. It is also concluded that *all* categories of project costs should have the same percentage cost share apply to them. Finally, Federal cost sharing might be used as an incentive to encourage local interests to comply with minimum land use requirements that would prevent shoreline damages.

**NBSIR 73-297. Fracture and deformation of alumina**, S. M. Wiederhorn, 14 pages (July 31, 1973). Order from NTIS as AD 772066.

Key words: electron microscopy; fracture; mechanical properties; plastic deformation; sapphire; sodium chloride.

This report summarizes work conducted during the past eight years on the fracture and deformation of ceramic materials. Accomplishments discussed in this report include: an elucidation of fracture process of aluminum oxide and sodium chloride; the development of techniques to study the deformation of aluminum oxide during abrasion; and the development of techniques for measuring fracture mechanics parameters on ceramic materials.

**NBSIR 73-304. Reference-waveform generation using Debye dielectric dispersion**, N. S. Nahman, R. M. Jickling, and D. R. Holt, 98 pages (Dec. 1972). Order from NTIS as COM 74-10281.

Key words: pulse distortion in transmission lines; pulse techniques; reference waveform generation; time domain measurements; transient response Debye dielectric.

This report discusses the theory, construction, and operation of Reference-Waveform Generators using a tunnel diode transition-waveform generator driving 4.65 meter (15 foot), 3.10 meter (10 foot), and 1.55 meter (5 foot) liquid-dielectric uniform lossy coaxial lines to produce known 0.2 volt transition waveforms across 50 ohms with (10-90%) transition times from 205 to 560 picosecond. Each resultant Available-Waveform is characterized in terms of its departure from the step response of the uniform lossy coaxial line operating into a 50 ohm load. The liquid dielectric solutions are dispersive with relaxation times of the order of 4 picoseconds in which heptane is the solvent and the ketones, butanone, heptanone and octanone are the solutes in concentrations ranging from 0.25- to 2-molal.

**NBSIR 73-316. Liquid helium pumps**, P. M. McConnell, 90 pages (June 1973). Order from NTIS as AD 769542.

Key words: cavitation; helium; pump performance; pumps; superfluid.

This report summarizes studies of pump characteristics and performance in supercritical, normally boiling, and superfluid helium, and also presents results on a survey of commercially available pumps for helium service. Experimental measurements were made on a centrifugal pump which produced a maximum head of about 15 meters and a maximum flow of about  $2.5 \times 10^{-4}$  m<sup>3</sup>/s. Performance agreed approximately with classical affinity laws, but cavitation appeared to provide less of a performance

limitation than expected. The survey turned up several pumps which have been used in helium, though relevant performance data is lacking.

**NBSIR 73-329. Theory of adjoint reciprocity for electroacoustic transducers**, A. D. Yaghjian, 78 pages (Feb. 1974). Order from NTIS as COM 74-10608.

Key words: adjoint operators; electroacoustic transducers; reciprocity; scattering matrices.

Analytical techniques for the measurement of the external characteristics of electroacoustic transducers have been developed by D. M. Kerns using a plane-wave scattering-matrix (PWSM) formulation. Foldy and Primakoff, in their classic papers on linear electroacoustic transducers, utilize a spatial impedance-matrix (SIM) formulation. Both formulations involve a continuous, linear "matrix" transformation in which reciprocity is defined as a relationship between elements of the matrix.

The first portion of the present report demonstrates that a transducer satisfying the "SIM relations" also satisfies the "PWSM equations" (but that the converse theorem does not hold), and that the alternate expressions of reciprocity are equivalent for transducers that obey both formulations.

The second portion of the report examines the equations which characterize the internal behavior of a large class of electroacoustic transducers. A linear operator approach is employed to develop a generalized reciprocity lemma which is used to establish adjoint reciprocity relations between the fields of a given transducer and its adjoint transducers. The linear operator approach facilitates the identification of self-adjoint (reciprocal or antireciprocal) transducers, and the adjoint reciprocity relations have utility in the extrapolation techniques of the PWSM formulation. An adjoint "reciprocity theorem" and "principle of reciprocity" are derived from the generalized reciprocity relations. Finally it is shown that the total power inputs for the adjoint transducers belong to the same "value class" as the original transducer.

**NBSIR 73-330. Frequency domain measurement of baseband instrumentation**, N. S. Nahman and R. M. Jickling, 68 pages (July 1973). Order from NTIS as COM 74-10609.

Key words: bandwidth; diode; impedance; sampling; slotted line.

Microwave measurement techniques were developed for characterizing the wideband feed-through sampling heads associated with time domain sampling oscilloscopes and frequency domain network analyzers. Such characterization or modeling is necessary for the removal of the oscilloscope distortion from the observed waveform to yield the input waveform; also, it is useful for extrapolation in estimating oscilloscope performance at higher frequencies.

The techniques were developed through measurements on a sampling oscilloscope having a 28 picosecond transition time (10 to 90%) and a 12.4 GHz baseband bandwidth. The major results of the work are the development of voltage and impedance measurement techniques which provide the means for determining the sampling-head equivalent circuit parameters. The techniques are based upon slotted-line measurements and are not inherently limited to any particular frequency range. Experimental results were obtained for the sampling-head input impedance over the 7-12 GHz frequency range, and for the 10 GHz sampling loop impedance (vs. sampling-diode bias current).

**NBSIR 73-331. Refrigeration of superconducting rotating machinery**, V. D. Arp, 75 pages (June 1973). Order from NTIS as COM 74-10238.



**Key words:** equation of state; helium; hydrodynamics; near-critical flow; refrigeration; superconductors; thermodynamics.

Recent work at the NBS Cryogenics Division in three areas related to helium refrigeration is summarized: (1) Analysis is given of a possible high pressure refrigeration cycle which offers in principle a reduced component size, but which turns out to be impractical because of expansion engine inefficiencies. (2) Exact equations for flow of a real fluid are derived and applied to problems of fluid flow near the critical point, as may occur with some helium-cooled superconducting systems, and (3) Three new equations of state for helium are given, each using different state variables, to eliminate the need for iterative techniques in helium refrigeration cycle and fluid flow analysis.

**NBSIR 73-335. Calibration of radio receivers to measure broadband interference,** E. B. Larsen, 75 pages (Sept. 1973). Order from NTIS as COM 74-11051.

**Key words:** broadband interference; field strength meter; impulse standards; receiver bandwidth calibration; spectral intensity.

This report covers one phase of a project to improve the accuracy for calibrating field-strength to measure broadband signals, especially impulse interference. The amplitude of a narrowband signal is commonly expressed in  $\mu\text{V}$ , and a broadband signal is expressed in  $\mu\text{V}/\text{MHz}$  bandwidth. A future report (2nd phase) will deal with standards and techniques for producing a known impulse field to calibrate an antenna-receiver system in  $\mu\text{V}/(\text{m} \cdot \text{MHz})$ . The technique used for initial calibration of a receiver as an RF voltmeter is new, employing a special L-pad with 48  $\Omega$  input resistor and 2  $\Omega$  output resistor across the receiver. The input power across 50  $\Omega$  is leveled, producing a low-impedance, constant-voltage source at the receiver input terminal.

Broadband interference is generally divided into two types: (a) random noise is best characterized by its power spectral density, and (b) impulse interference (uniform periodic pulses) is best quantified by its impulse strength. Several possible approaches were evaluated for defining and measuring various bandwidths of a receiver. The response of a receiver to impulses, as measured with a peak-reading detector, is proportional to the product of receiver impulse bandwidth and signal impulse strength. Of the two types of impulse sources evaluated here (pulsed DC and pulsed RF), the latter appears to be the most accurate and repeatable. We were able to produce a clean RF pulse, choosing an effective duration of 0.1  $\mu\text{s}$  in our experiments, which covered a frequency range of 100 to 1000 MHz. The worst-case uncertainty of this standard source for calibrating receiver impulse bandwidth is  $\pm 0.7$  dB.

**NBSIR 73-339. Preliminary hydrogen freezing studies,** D. E. Daney, W. G. Steward, and R. O. Voth, 281 pages (Oct. 1973). Order from NTIS as COM 73-11985/1GA.

**Key words:** freezing rates; solid hydrogen; thawing; thermal conductivity.

The study summarized in this report is aimed at developing the technology required to fill space vehicle propellant tanks with solid hydrogen by in-place freezing. Planned continuation of this work was terminated with the loss of NERVA funding by the NASA. Therefore, progress to-date is summarized but substantial experimental results have not yet been obtained.

The program was to have been carried out in two phases: a mathematical analysis and experimental verification of the analysis. Freezing times and heat flux have been calculated for four geometrical shapes, and a range of sizes, refrigerant temperatures, ortho-para concentrations, and heat transfer coefficients. The results of these calculations are presented in generalized graphical form, in a total of 240 graphs.

The freezing experimental apparatus has been built and a preliminary test performed which generally demonstrates the validity of the analytical and experimental approaches. With only minor modifications the apparatus is ready for a full test program of hydrogen freezing and melting techniques.

**NBSIR 73-341. Test results for the Mooring Line Data Line,** D. A. Ellerbruch, 46 pages (Oct. 1973). Order from NTIS as COM 74-10885.

**Key words:** characteristic impedance; coupler; current; impedance, input impedance; Mooring Line Data Line; propagation characteristics; transmission line.

Results obtained from the Mooring-Line-Data-Line (MLDL) measurements program are presented. Frequency and time domain measurements are made to determine characteristics impedance, input impedance, current, and propagation parameters. Most of the measurements were made with an MLDL deployed specifically for this program; however, some were made on an MLDL deployed buoy.

**NBSIR 73-342. The thermophysical properties of methane, from 90 to 500 K at pressures to 700 bar,** R. D. Goodwin, 279 pages (Oct. 1973). Order from NTIS as COM 73-11978/IAS.

**Key words:** densities; enthalpies; entropies; equation of state; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; PVT data; specific heats; speeds of sound; vapor pressures.

Thermophysical properties of methane are tabulated at uniform temperatures from 90.68 to 500 K along isobars to 700 bar. A novel equation of state is employed for the first time, having origin on the vapor-liquid coexistence boundary. Computations are based almost entirely on ideal gas specific heats and experimental  $P$ - $\rho$ - $T$  data via the equation of state, without weighting to data for derived properties. Good agreement with such data confirms validity of the equation and method. New  $P$ - $\rho$ - $T$  data are reported at 0.3 to 1.7 times the critical density.

**NBSIR 73-344. Heat transfer and mixing of slush hydrogen,** C. F. Sindt and P. R. Ludtke, 40 pages (Nov. 1973). Order from NTIS as COM 74-10749.

**Key words:** heat transfer; liquid hydrogen; mixing; mixing power; paddle mixers; slush hydrogen; turbine mixers.

Heat transfer to slush hydrogen and mixing were investigated in a 1  $\text{m}^3$  cylindrical vessel. The effects of heat transfer rates on thermal stratification and on self-pressurization were measured. Temperature profiles in thermal stratification were found to be more dependent on slush level and slush settling rates than on liquid level. Solids in the slush appear to be involved in the heat transfer mechanism as slush level affected the amount of warm liquid reaching the top of the dewar and therefore affected the self-pressurization rates.

Mixing effectiveness and power requirements to mix slush hydrogen were determined for two configurations of turbine mixers and one paddle mixer. Mixing power requirements were found to be sensitive to the mixer location and configuration.

**NBSIR 73-345. Combustion of metals in oxygen phase II: Bulk burning experiments,** A. H. Tench, H. M. Roder, and A. F. Clark, 49 pages (Dec. 1973). Order from NTIS as COM 74-10239.

**Key words:** alloys; aluminum; combustion; ignition; oxygen; safety; stainless steel; steel, titanium.

This program was started to study combustion of the ordinary metals in oxygen, to provide information useful to designers of bulk oxygen handling equipment, particularly from the point of view of safety. We have studied the ignitability and combustibili-



ty of carbon steels, stainless steels, aluminum alloys, titanium and copper metals, in oxygen atmospheres up to 60 psig. We encountered a violent reaction involving burning stainless steel and aluminum, a thermite reaction apparently, and have investigated this from a quantitative point of view. We have tried throughout to study the quantitative aspects of the combustion processes, and related quenching effects. Ordinary steel and stainless steel burn quite readily at these low oxygen pressures, and the stainless steel-aluminum reaction produces intense heat, with severe damage to neighboring structures. We are at the stage where further investigations could be carried out quite expeditiously and on a sound statistical basis.

**NBSIR 73-346. RF total mass gauging in large storage containers: Empty tank modes**, R. S. Collier and D. Ellerbruch, 28 pages (Oct. 1973). Order from NTIS as COM 74-10240.

Key words: LOX storage container; radio frequency; total mass gauging.

This report describes experiments to determine the feasibility of radio frequency (RF) mass gauging for fluids stored in large containers. The experiments were done at the NASA Mississippi Test Facility using the 460,000 gallon LOX Storage Tank as an electromagnetic resonant cavity. The results show that the RF gauging technique is feasible for large containers.

**NBSIR 73-347. Active and passive mode locking of continuously operating rhodamine 6G dye lasers**, A. Scavennec and N. S. Nahman, 54 pages (Feb. 1974). Order from NTIS as COM 74-10674.

Key words: DODCI; dye laser; laser; mode-lock; picosecond; rhodamine 6G.

Using confined and unconfined fluid flow dye cells with suitable mode locking methods continuously operating rhodamine 6G dye lasers have been built to produce narrow pulses (less than 40 ps) at about a 140 MHz pulse repetition rate. For active (acoustic) amplitude modulation mode locking methods optical pulses were obtained having about a 32 ps pulse width (FWHM). For passive mode locking methods optical pulses of  $\leq 35$  ps pulse width (FWHM) were obtained.

A three mirror cavity was used for the active mode locking studies while three and five mirror cavities were used in the passive studies. The three mirror passive mode locked laser employed a single dye cell containing both the rhodamine 6G (gain) and DODCI (loss) solutes in a single solution having glycol as the solvent. The active and passive mode locked carrier wavelengths were about 5900 Å and 5800 Å, respectively.

**NBSIR 73-348. An engineering feasibility study for one-way time transfer using the GOES satellite ranging system**, J. B. Milton and W. F. Hamilton, 38 pages (Dec. 1973). Order from NTIS as COM 74-10241.

Key words: clock synchronization; one-way time transfer; satellite timing; synchronous satellite.

The Time and Frequency Division of the National Bureau of Standards has conducted an engineering study to determine the feasibility of using the GOES satellite ranging system for precise (0.1 microsecond, one-sigma) time transfer to a receiving-only timing site. The GOES satellite ranging system, termed a trilateration system, will accurately locate this satellite within some coordinate structure. The sources of time transfer errors have been studied in some detail. These errors can be caused by satellite location errors, ground station location errors, unknown delays caused by the troposphere, the ionosphere, and the various equipments. Simplified designs for an automatic and a manually operated timing site are presented. Some technical problems found in the associated equipment are discussed. The study indicates that a secondary, or slave site, clock could be

synchronized to within 0.1 microsecond; one-sigma, of some master clock utilizing a one-way, or receiving-only system.

**NBSIR 73-349. Characterization of a superconducting coil composite**, C. W. Fowlkes, P. E. Angerhofer, R. N. Newton, and A. F. Clark, 51 pages (Dec. 1973). Order from NTIS as COM 74-10241.

Key words: composite; low temperature; Poisson's ratio; superconductor; thermal expansion; Young's modulus.

The superconducting coil composite material being utilized by the Annapolis Laboratory of the Naval Ship Research and Development Center is characterized by its mechanical and thermal properties. The Young's moduli, Poisson's ratios, and thermal contractions are measured from room temperature to 4K and reported in this interim report. A micromechanical analysis based upon volume fractions of constituents is used to predict room-temperature properties, and a comparison is made to the measured values.

**NBSIR 73-351. Thermal conductivity standard reference materials from 6 to 280 K: VI. NBS sintered tungsten**, J. G. Hust, 58 pages (Jan. 1974). Order from NTIS as AD 775367.

Key words: cryogenics; electrical resistivity; Lorenz ratio; Seebeck effect; standard reference material; thermal conductivity; transport properties; tungsten.

Thermal conductivity, electrical resistivity, Lorenz ratio, and thermopower data are reported for two specimens of NBS sintered tungsten for temperatures from 6 to 280 K. Variability of this tungsten was studied by means of electrical resistivity and residual resistivity measurements on 39 specimens. These data indicate a material variability of about  $\pm 10$  percent in thermal conductivity at helium temperatures. Above 90 K variation in thermal conductivity is only about  $\pm 1$  percent. To reduce the uncertainty caused by specimen variation at low temperatures, characterization by residual electrical resistivity data is described. By this procedure the low temperature uncertainty is reduced to about  $\pm 3$  percent.

**NBSIR 73-402. NBS materials science and manufacturing in space research**, E. Passaglia and R. L. Parker, 127 pages (Nov. 1973). Order from NTIS as COM 74-10472.

Key words: materials processing; perfection; purity; space manufacturing; space processing; zero-g.

This report describes NBS work for NASA in support of NASA's Materials Science and Manufacturing in Space (MS/MS) (now Space Processing) program, covering the period November 1, 1972 to October 31, 1973. The objectives of the NBS program are to perform ground-based studies of those aspects of space that could possibly provide a unique environment for making materials more perfect or more pure. The approach taken deals primarily with experimental and theoretical studies of the possible effects of the absence of gravitational forces on those materials preparation processes where the presence of gravity may be important in reducing perfection or purity. The materials preparation processes studied comprise 5 tasks in the areas of crystal growth, purification and chemical processing, and the preparation of composites.

**NBSIR 73-403. Development and analysis of techniques for calibration of Kerr cell pulse-voltage measuring systems VII**, E. C. Cassidy, R. E. Hebner, R. J. Sojka, and M. Zahn, 129 pages (Nov. 1, 1973). Order from NTIS as COM 74-10016/5GA.

Key words: electric field measurement; electro-optic Kerr effect; high voltage measurement; impulse measurement; Kerr constant; liquid insulants; nitrobenzene; peak reading voltmeter; space charge.

To improve the accuracy of pulse voltage systems using the



electro-optic Kerr effect, it is necessary to improve the accuracy of calibration of Kerr cells. In the past this has been attempted by calibrating the cell under direct voltage and relying on the frequency independence of the Kerr coefficient (below  $10^8$  Hz) to insure that the calibration was valid under high voltage pulses. Space charge effects, however, modify the electric field distribution in the liquid under direct high voltage. The electric field and space charge behavior in nitrobenzene have therefore been documented as functions of the level and frequency of the applied voltage. In addition, to improve the efficiency of cell design and to facilitate the investigation of other liquids for use in Kerr cells, the electro-optic Kerr coefficient of nitrobenzene has been measured as a function of temperature and wavelength. Finally a new peak reading voltmeter based on the Kerr effect is described and the results of using the electro-optic Kerr effect to measure the voltage pulses in medical x-ray machines are presented.

**NBSIR 73-404. Mass transport and physical properties of large crystals of calcium apatites: Studies of  $\text{Ca}(\text{OH})_2$  crystals for use in electrolytic conversion of calcium fluorapatite crystals to calcium hydroxyapatite,** A. D. Franklin and K. F. Young, 37 pages (Sept. 1, 1972-Aug. 31, 1973). Order from NTIS as PB 203952.

Key words: ac impedance; calcium apatites; calcium hydroxide; crystal growth; electrolysis; interfacial polarization; ionic conduction; mass transport.

In order to convert single crystals of calcium fluorapatite to calcium hydroxyapatite, an electrolytic cell technique will be explored. To utilize such a technique, the cathode compartment must consist of a source of hydroxyl ions and a barrier to the flow of all others. Examination of the literature on metallic hydroxides suggests that a suitable cathode might be composed of an oriented  $\text{Me}(\text{OH})_2$  crystal, where Me is Mg, Ca, Sr, or Ba, backed up by a Pt electrode in an atmosphere containing  $\text{H}_2\text{O}$  and  $\text{O}_2$ .  $\text{Ca}(\text{OH})_2$  crystals have been grown from aqueous solution, and Pt electrodes evaporated onto them. An apparatus has been built to study their ac admittance as a function of temperature and atmosphere, and measurements begun. A computer program for handling the complex admittance data has been devised and tested.

**NBSIR 73-405. Use of organic coatings on the interior surfaces of equestrian statues at Memorial Bridge Plaza,** F. Ogburn, 9 pages (Nov. 1973). Order from NTIS as COM 74-10131.

Key words: bronze statuary; organic coatings; restoration; statues.

The equestrian statues at Memorial Bridge Plaza in the District of Columbia are bronze castings. The exterior finish is subject to corrosion processes associated with pores and cracks in the castings. The interior surfaces are subjected to high humidity and condensation. Detrimental corrosion is expected only at discontinuities in the plated coatings on the exterior surfaces. Painting of interior surfaces has been recommended, but the need for painting is not clear. The NCP is advised to keep the statues under close observation till the fall of 1974 and then reconsider their course of action.

**NBSIR 73-406. Reference materials for the determination of trace elements in biological fluids,** P. D. LaFleur, 22 pages (Dec. 1973). Order from NTIS as COM 74-11352.

Key words: arsenic; biological fluids; chromium; copper; fluorine; lead; nickel; reference materials; selenium; trace elements; urine.

The preparation of a number of reference materials for the analysis of trace elements in biological standards is described. The standards produced include mercury in urine at three concentration levels, five elements [Se, Cu, As, Ni, Cr] in freeze-

dried urine at two levels, fluorine in freeze-dried urine at two levels, and lead in whole blood at two concentration levels. These reference materials have been analyzed for the element(s) of interest by one or more analytical techniques, and are supplied with known concentration levels.

**NBSIR 73-407. Report on a pre-test of a survey plan for estimating incidence of lead based paint,** L. S. Joel and H. W. Berger, 86 pages (Dec. 1973). Order from NTIS as COM 74-11078.

Key words: lead; lead paint poisoning; paints; poisoning; retail inventory; statistics; survey.

Lead in paint has been indicted as a major cause of lead poisoning of children. Federal regulations have been established to limit the amount of lead which may be added to paints that are intended for residential use. The intent of such a limitation is to curtail the incidence of present and future lead based paint poisoning of children.

This report presents the results of a "pre-test" for a nationwide survey plan that would be used to determine the availability, to the public, of paints that may contain lead compounds in hazardous quantities. Statistical summaries of the chemical analysis of 250 paints purchased by random selection at five retail outlets, are presented along with comments regarding the possible implications of those results. Recommendations are made about survey action beyond the pre-test described herein.

**NBSIR 73-412. The incidence of hazardous material accidents during transportation and storage,** W. A. Steele, D. Bowser, and R. E. Chapman, 40 pages (Nov. 1973). Order from NTIS as COM 74-10512.

Key words: accidents; hazardous material; storage of hazardous material; transportation of hazardous material.

This report is one of a series describing background research concerning the incidence of abnormal loading. The report is organized in terms of modes of hazardous material transportation and storage. These modes—pipeline, water, motor vehicle, and railroad transportation systems—are addressed in four sections with Storage Systems discussed in a fifth. The sections depend on the amount of available data, rather than the risk involved in an accident. A summary of the results is presented in the last section. On the whole, there is little empirical evidence to substantiate a threat to buildings from hazardous materials transport. However, trends in volumes shipped in proximity to structures of interest raises the prospect of future incidents.

**NBSIR 73-413. Measurement of depth-dose distributions in carbon, aluminum, polyethylene, and polystyrene for 10-MeV incident electrons,** J. C. Humphreys, S. E. Chappell, W. L. McLaughlin, and R. D. Jarrett, 54 pages (Nov. 1973). Order from NTIS as COM 74-10750.

Key words: aluminum; carbon; depth dose; depth-dose distributions; dye-film dosimeters; polyethylene; polystyrene; radiochromic dyes; 10-MeV electrons.

Depth-dose distributions of 10-MeV electrons incident on homogeneous media of carbon, aluminum, polyethylene, and polystyrene have been measured using thin radiochromic dye-film dosimeters. Two types of dye-film dosimeters were employed as "cavities" within the media in two different geometrical configurations. One configuration was a stack with the dosimeters interleaved between disks of the medium and placed perpendicular to the incident electron beam direction. The other configuration was a wedge assembly with a single piece of dye film placed between pieces of the medium at a small angle to the beam direction. The results show no significant difference between dosimeter type or experimental arrangement. In addition, good agreement is shown in comparisons of experimental and Monte Carlo calculated depth-dose distributions charac-



terized by such parameters as extrapolated range, depth of peak dose, and ratio of peak to entrance dose.

**NBSIR 73-414. Building and evaluation of a polluted air delivery system,** G. P. Baumgarten and F. W. Ruegg, 36 pages (Apr. 1974). Order from NTIS as COM 74-10866.

**Key words:** air pollution; critical flow; laminar flow; nozzle; porous plug; sulfur dioxide concentration.

The building and evaluation of a prototype SO<sub>2</sub> polluted air delivery system (PADS) is discussed. The delivery system was built to deliver sulfur dioxide (SO<sub>2</sub>) in air at a rate of 5 liters per minute with design concentrations by volume of 1.0, 0.1 and 0.01 parts per million. It consists of a diluent air delivery system utilizing a critical flow sonic nozzle and three separate concentrated SO<sub>2</sub> in air flow systems utilizing laminar flow porous plugs, one plug for each desired output concentration. The delivery system is contained in a dispatch case and the two gases are delivered to it from pressurized containers through detachable supply lines. Prospective use by unskilled technicians dictated simplicity and durability and compactness.

By maintaining specific upstream pressures on the critical flow nozzle and the laminar flow porous plugs of 45 and 12 psig respectively, the prototype PADS produced average output concentrations of 0.76, 0.100 and 0.003 parts per million of SO<sub>2</sub> in air based on concentration measurements with an NBS calibrated analyzer. The expected output concentrations were 0.98, 0.105 and 0.010 respectively, based on flow calibrations of the individual components. The uncertainty of the output concentration is estimated to be about  $\pm 10$  percent.

**NBSIR 73-416. Report on meeting of ISO/TC 6/SC 5 testing methods and quality specifications for pulp,** W. K. Wilson, J. H. Schulz, C. E. Brandon, and J. L. Borstelmann, 69 pages (Nov. 16, 1973). Order from NTIS as COM 74-10511.

**Key words:** ISO recommendations; pulp; pulp, testing methods; testing methods for pulp.

The ninth meeting of ISO/TC 6, Paper, SC 5, Testing Methods for Pulp, was held in Madrid, Spain, November 2-8, 1973. Over 30 delegates from 11 countries discussed methods for testing of pulp and, to some extent, paper. Methods were agreed upon for the determination of saleable mass of flash dried pulp, disintegration of pulp, laboratory beating of pulp, preparation of laboratory sheets, and measurement of ISO brightness of pulp. It was agreed that ISO Recommendations for determination of saleable mass of pulp in lots, determination of dry matter content, and determination of trace metals in pulp should be revised. Plans were made to continue studies of methods for the determination of viscosity, aqueous extraction, dirt and shives, total sulphur content, saleable mass of unitized lots of pulp, statistical evaluation of number of sample bales, preparation of laboratory sheets, and fiber classification and drainability.

**NBSIR 73-417. Evaluation of commercial integrating-type noise exposure meters,** W. A. Leasure, Jr., R. L. Fisher, and M. A. Cadoff, 33 pages (Dec. 1973). Order from NTIS as COM 74-10477.

**Key words:** acoustics (sound); dosimeter; environmental acoustics; instrumentation; noise exposure; noise exposure meters.

As a result of the promulgation of occupational noise exposure regulations by the Federal government, there are a number of commercial noise exposure meters on the market today that provide a measure of noise integrated (with appropriate weighting) over a time interval. This report presents the results of an evaluation of such instruments by the National Bureau of Standards (under the sponsorship of the U.S. Environmental Protection Agency) as to their usefulness in monitoring compliance with oc-

cupational noise regulations as well as their applicability as instruments for use in achieving the broader goals of the EPA. Tests were designed and conducted to evaluate microphone and system response to sound of random incidence, frequency response, crest factor capability, accuracy of the exchange rate circuitry, performance of the noise exposure meter as a function of temperature, and the dependence of the device on battery voltage. The rationale of the test procedures utilized to evaluate overall system as well as specific performance attributes, details of the measurement techniques, and results obtained are discussed.

**NBSIR 73-418. Test methods for determining coaxial cable response to bending strain, bulk compression (hydrostatic pressure), axial strain, and torsional strain,** J. F. Mayo-Wells, S. Edelman, and J. Jacobs, 119 pages (July 1973). Order from NTIS as COM 74-11783.

**Key words:** cable; coaxial; mechanical; response; strain.

Test methods have been developed for measuring the response of specimen one-meter lengths of coaxial cables, considered as sensing elements, to four separate types of strain: bending strain, bulk compression, axial tension, and torsional strain. Measurements were made on commercially available coaxial cables made in the laboratory from insulated wire and wire braid. Cable dielectric materials investigated include tetrafluoroethylene (TFE), fluorinated ethylene propylene (FEP), cellular FEP, polyethylene, cellular polyethylene, and polyvinyl chloride. Data from the measurements are included in appendixes.

**NBSIR 73-420. Survey on metallic implant materials,** J. R. Parsons and A. W. Ruff, 55 pages (Dec. 1973). Order from NTIS as COM 74-11092.

**Key words:** biomaterials; corrosion; implant materials; mechanical properties; metals.

The application of metallic materials as orthopedic implants in the human body is reviewed, concentrating on materials presently in clinical use and undergoing laboratory evaluation for possible future use. The criteria considered explicitly are tissue compatibility, mechanical properties, corrosion resistance, and toxicity. The three principal metallic implant materials, stainless steel, cobalt alloys, and titanium, are discussed in detail. Wherever possible, comparisons are made between the materials in terms of the intended application.

**NBSIR 73-421. An overview of the factors impacting metrication of the U.S. housing industry,** R. G. Hendrickson and D. W. Corrigan, 35 pages (Dec. 1973). Order from NTIS as COM 74-11224.

**Key words:** codes; construction conference; domestic housing, U.S.; foreign metrication; levels of conversion; metrication; problems of metrication.

This report describes the work undertaken by the National Bureau of Standards for the Department of Housing and Urban Development to ascertain and delineate major problems associated with the metrication of the domestic housing industry of the United States. Source material for the study included, principally, the foreign experiences of Great Britain and Australia; information obtained from interviews with businesses and associations; depositions provided to the 1970 Construction Conference, held for the purposes of the U.S. Metric Study; and documents, both foreign and domestic, pertaining to aspects of metrication.

The results of the study indicate the critical impact of metrication will be the redefinition or accommodation of the 15,000 codes at the local level, and the coordination of the 127 standard-setting organizations in the United States to define, develop and



implement standards consonant with requirements and desired industry goals.

**NBSIR 73-422. A study of air traffic data requirements and sources for FAA analyses,** W. F. Druckenbrod, J. F. Gilsinn, R. H. F. Jackson, L. S. Joel, and T. K. Ming, 51 pages (May 1974). Order from NTIS as COM 74-11240.

Key words: air traffic analyses; air traffic data; standard reference air traffic data; users of air traffic data.

This report describes activities undertaken to assess the practicability of establishing a single file or a set of files of standard reference air traffic data samples. These files would serve as a common data base for ongoing and anticipated future forecast and analytical investigations relevant to the accommodation of air traffic in the National Airspace System.

The study entailed surveys of past and present air traffic data collection activities, of existing data files, and of all identifiable users of air traffic data within the FAA, as well as FAA contractors whose work requires air traffic data.

The information resulting from these surveys has been evaluated and aggregated to identify data which will satisfy most of the requirements expressed by the data users. Two data sets are specified for terminal area requirements, two sets for enroute requirements, and one set for oceanic requirements. These data sets will satisfy most input requirements for all anticipated analysis efforts. However, depending on the type of study, supplemental information, which is identified in various parts of this report, will be required in some cases.

**NBSIR 73-424. A study of young children's pull-apart strength (an addendum to NBSIR 73-156—a study of the strength capabilities of children ages two through six),** W. C. Brown, C. J. Buchanan, and J. Mandel, 17 pages (Apr. 1974). Order from NTIS as COM 74-10867.

Key words: children; children's strength; pull-apart; safety; strength; test methods; toys; toy safety.

The Child Pull-Apart Strength Study was conducted to provide information which can be used to develop reliable and realistic standards and test methods for children's toys. The study was conducted with over 500 children in the Washington Metropolitan area, and included both black and white children from varying economic and social backgrounds.

The pull-apart test device used is a prototype model designed and constructed at the National Bureau of Standards. This test device was designed to measure the force that children can exert when pulling an object apart.

The results of the pull-apart strength study are consistent with those obtained in the previous child strength study which dealt with twisting, pulling, pushing, and squeezing (NBSIR 73-156). The study provided quantitatively precise and useful information about the effects of age and sex on the pull-apart strength capability of children ages two through six. The results are exhibited in tables of averages, standard deviations, coefficients of variation, and 95th and 5th percentiles.

**NBSIR 74-357. A modified Benedict-Webb-Rubin equation of state for parahydrogen,** R. D. McCarty, 74 pages (Feb. 1974). Order from NTIS as COM 74-10551.

Key words: critical point; equation of state; hydrogen; index of refraction; PVT; saturation properties; scaling laws.

A 32 term modified Benedict-Webb-Rubin equation of state has been applied to data for parahydrogen. The adjustable parameters in the equation of state were determined using data from the triple point to 2500 K, with pressures to 680 atmospheres. Extensive modifications have been made to the previously accepted PVT surface for the saturated liquid and

vapor phases in the near critical region. These modifications have been made on the basis of subsequent refractive index data and the application of scaling law equations. Comparisons between experimental and calculated data are given.

**NBSIR 74-359. Semi-annual report on materials research in support of superconducting machinery,** L. L. Sparks, F. R. Fickett, J. G. Hust, P. J. Giarratano, H. M. Ledbetter, E. R. Naimon, W. F. Weston, M. B. Kasen, R. L. Tobler, R. P. Mikesell, R. L. Durcholz, C. W. Fowlkes, and R. P. Reed, 313 pages (Mar. 1974). Order from NTIS as AD 780596.

Key words: composites; fracture; liquid helium; mechanical properties; structural materials; superconducting machinery; thermal conductivity.

Results of six months research are reported to the sponsor, the Advanced Research Projects Agency of the Department of Defense. Subjects include magneto-thermal conductivity, thermal conductivity, composites, elastic properties, fracture toughness, fatigue, and tensile. All measurements include the temperature range 4 to 300 K. Materials examined are those either presently being used in superconducting machinery or considered for use in future prototypes. Material classes include stainless steels, inconels, titanium alloys, and composites.

Special results include: the thermal conductivity in a magnetic field is considerably lower than would be predicted; a comprehensive review of glass-reinforced composite behavior at low temperatures is included; the elastic moduli of 12 engineering alloys from 4 to 300 K are reported; and fracture toughness and fatigue crack growth rate data on AISI 304, AISI 316, A286, Ti-5Al-4V and Ti-6Al-2.5 Sn at 4, 76 and 300 K have been measured.

**NBSIR 74-361. Electromagnetic interference measurements at ASA, Fort Huachuca, Arizona,** H. E. Taggart and J. W. Adams, 72 pages (Dec. 1973). Order from NTIS as COM 74-11222.

Key words: APD; field strength; interference; power lines.

This report describes the work performed for the U.S. Army Security Agency Test and Evaluation Center (USASATEC), Fort Huachuca, Ariz. during the period from April 1973 to November 1973. The purpose of the project was to measure, analyze, and evaluate the electromagnetic environment at selected sites and to recommend methods of reducing the present levels of electromagnetic interference (EMI). The chief sources of EMI were the power lines in the area and sferics from thunderstorms. Both broadband EMI measurements and amplitude probability distribution measurements were made. Both electric and magnetic fields were measured. The frequency range covered was 15 kHz to 10 GHz. Measurements were made at three locations: 1) at Fort Huachuca USASATEC; 2) Willcox Dry Lake; and 3) Boulder, Colo. The report contains the test results, conclusions, and recommendations.

**NBSIR 74-363. Heat transfer in pulsed superconducting magnets,** V. Arp, P. J. Giarratano, R. C. Hess, and M. C. Jones, 137 pages (Jan. 1974). Order from NTIS as COM 74-11053.

Key words: forced convection heat transfer; pulsed power systems; pulsed superconducting magnets; superconductor losses; supercritical helium; transient heat transfer.

The first section of this report summarizes design problems for the development of advanced superconducting pulse magnets, leading to recommendations for future work, primarily in (1) evaluation of eddy-current, hysteresis, and frictional losses, and (2) transient heat transfer between the superconductor and the helium. Two subsequent sections report measurements of forced convection heat transfer respectively to subcooled liquid helium and to supercritical helium just above the critical pressure.



**NBSIR 74-364. Detection of human intruders by low frequency sonic interferometric techniques**, R. E. Stoltenberg, 94 pages (May 1974). Order from NTIS as COM 74-11208.

Key words: human detector; interferometric technique; low frequency acoustics.

This report examines the theory and evaluates the results of over 200 tests of the use of low frequency sonic interference techniques for the detection of a human intruder in a confined area. The conclusions are that this technique is potentially a significant improvement over conventional methods with regard to area coverage and minimum velocity detection.

This work examined the intruder signature and background noise with respect to sonification frequency, source levels, intruder size, intruder velocity, source types, area coverage (to 692 sq. meters), and geometric position of the source and receiver in four radically different areas.

Interference effects of the intruder signature and noise were analyzed with respect to bandwidth, spectral content, and magnitude by both computer drawn spectral displays, and specific frequency correlators.

**NBSIR 74-365. Impulse spectral intensity—what is it?**, M. G. Arthur, 25 pages (May 1974). Order from NTIS as COM 74-11375.

Key words: electromagnetic interference; Fourier transform; impulse spectral intensity; spectral intensity; spectrum amplitude; spectrum amplitude density.

The term, impulse spectral intensity, is often used in discussions concerning electromagnetic interference and broadband signal processing. In these discussions, the term is not used in a consistent manner, resulting in confusion, equivocation, and sometimes, errors. As a step towards improving this situation, the mathematical basis for spectral intensity is reviewed and certain of its features are clarified. Also, misuses of spectral intensity are discussed, along with its limitations and proper use.

**NBSIR 74-366. Study of cryogenic propellant systems for loading the space shuttle**, R. O. Voth, W. G. Steward, and W. J. Hall, 95 pages (Apr. 1974). Order from NTIS as COM 74-11076.

Key words: computer modeling; cooldown; cryogenic flow; stresses; surges; transient flow; water hammer.

Computer programs have been written to model the liquid oxygen loading system for the space shuttle. The programs allow selection of input data through graphic displays which schematically depict the part of the system being modeled. The computed output is also displayed in the form of graphs and printed messages. Any one of six computation options may be selected. The first four of these pertain to thermal stresses, pressure surges, cooldown times, flow rates and pressures during cooldown. Options five and six deal with possible water hammer effects due to closing of valves, steady flow and transient response to changes in operating conditions after cooldown.

Procedures are given for operation of the graphic unit and minicomputer.

**NBSIR 74-369. Surface magnetic field noise measurements at Geneva Mine**, J. W. Adams, W. D. Bensema, and N. C. Tomoeda, 40 pages (June 1974). Order from NTIS as COM 74-11688.

Key words: earth-ionosphere waveguide; electromagnetic noise; EMI measurement technique; spheric interference.

Measurements of surface magnetic field noise were made at various locations over the Geneva Coal Mine near Price, Utah, on June 12, 1973. The locations selected were on the surface over emergency locator beacons underground at depths between

350 meters (1150 ft.) and 488 meters (1600 ft.). The surface terrain where these measurements were made was mountainous, and access was difficult. There were no power lines within several miles, and the weather was clear; therefore, the magnetic noise levels were about as low as will normally occur.

Results of measurements of distant sferics indicate rather sharp cutoff frequencies below which broadband, impulsive noise is attenuated. The mechanism of propagation for this noise above the daytime cutoff frequency of 3500 Hz and the nighttime cutoff frequency of 1700 Hz is deduced to be a waveguide formed by the D or E layers of ionosphere as an upper plane and the earth as a lower plane.

The measurement systems used are similar to those used earlier. The technique is to record broadband, analog signals, digitize the data, and use a fast-Fourier transform to obtain spectral plots. This technique is novel in that it can measure simultaneously all magnetic field energy within a limited portion of the spectrum for a limited time, and, after processing, reproduce the events occurring in that time interval in great detail.

**NBSIR 74-375. Refrigeration for an 8 K to 14 K superconducting transmission line**, D. E. Daney, 60 pages (Oct. 1974). Order from NTIS as COM 74-11657.

Key words: Brayton cycle; refrigeration; superconducting transmission lines; superconductors.

The performance of three supercritical refrigeration cycles for cooling superconducting transmission lines has been investigated for the temperature range of 8 K to 14 K. This temperature range is applicable to the Stanford superconducting ( $\text{Nb}_3\text{Sn}$ ) line. These cycles, which were selected as being the most practical, are the Brayton cycle with the expander before the load, the Brayton cycle with the expander after the load, and the Brayton cycle with a separate supercritical helium loop and circulating pump.

The results are presented as curves of  $W_c/Q$  (ratio of the work of compression to the refrigeration load) vs the transmission line exit pressure for various transmission line pressure and temperature drops. Contrary to popular belief, all three cycles are competitive. Maximum efficiencies (percent of Carnot) are about 25 percent.

Estimated capital and operating costs are presented as a function of transmission line temperature for several values of thermal load per length of line.

**NBSIR 74-377. Picosecond pulse generators using microminiature mercury switches**, J. R. Andrews, 44 pages (Mar. 1974). Order from NTIS as COM 74-11449.

Key words: mercury switch; picosecond; pulse generator; pulse measurement; superconductivity.

Pulse generators have been built using microminiature mercury switches. A commercial RF coaxial switch was also evaluated as a pulse generator. A superconducting delay line ( $t_r = 18$  ps,  $t_d = 70$  ns) and a sampling oscilloscope ( $t_r = 22$  ps) were used to measure the generated pulse 10-90 percent transition time. The best result obtained was a transition time of 39 ps. Pulse amplitudes were independently adjustable up to 50 volts. The microminiature mercury switches in general were found to give very unreliable operation.

**NBSIR 74-378. Time and amplitude statistics for electromagnetic noise in mines**, M. Kanda, 59 pages. Order from NTIS as COM 74-11450.

Key words: Allan variance analysis; amplitude probability distribution; amplitude statistics; average crossing rate; electromagnetic interference; electromagnetic noise; impulsive noise; interpulse spacing distribution; magnetic field



strength; man-made noise; pulse duration distribution; time statistics.

The time and amplitude statistics necessary to adequately describe electromagnetic (EM) noise in mines are illustrated through computer software techniques. They are 1) Allan Variance Analyses (AVA), 2) Interpulse Spacing Distributions (ISD), 3) Pulse Duration Distributions (PDD), 4) Average Crossing Rates (ACR), and 5) Amplitude Probability Distributions (APD). These statistics are illustrated using data taken from a rather large store of raw analog data recorded in operational mines.

The curves generated for the illustrations characterize the noise environment in the mines from which the corresponding data were taken, and should aid in the design of reliable communication systems for such mines.

**NBSIR 74-380. Planar near-field measurements on high performance array antennas**, A. C. Newell and M. L. Crawford, 100 pages (July 1974). Order from NTIS as COM 74-11686.

Key words: antennas; near-field measurements; phased arrays.

The results of measurements which apply the planar near-field measurement technique to phased array antennas are described. Fast and efficient tests are used to determine the required scan area and data point spacing. The use of these tests can reduce the amount of data required for some antennas without significantly increasing the errors in computed results.

Measurements were made at different distances from the antennas, with the probe transmitting and receiving, and for both sum and monopulse difference patterns. Comparisons between the far-field patterns computed from the near-field data and those measured on far-field ranges are presented.

**NBSIR 74-382. A study of the measurement of G/T using Cassiopeia A**, D. F. Wait, W. C. Daywitt, M. Kanda, and C. K. S. Miller, 199 pages (June 1974). Order from NTIS as AD 783433.

Key words: accuracy; antenna; calibration; Cassiopeia A; G/T; star flux.

This report describes a study intended to estimate the best possible accuracy of measuring the ratio G/T (system gain to system noise temperature) of a satellite communication ground station using the radio star Cassiopeia A (Cas A). The concept of G/T and its measurement using a radio star is briefly discussed. Results of an extensive literature search are presented, summarizing the properties of Cas A and its vicinity described by radio astronomers in order to utilize this information to assess the accuracy of a G/T measurement. Consideration is given to atmospheric effects upon a G/T measurement using Cas A based on information available in the literature. A detailed analysis of errors for gain measurements of large ground antennas, which includes the calibration of a standard gain antenna and the transfer of the calibration of this standard to a large antenna, is provided to validate radio star flux data since this analysis is not available in the literature. The results of these efforts are utilized to show that the best possible accuracy of a G/T measurement for a ground station having a 60 ft. diameter antenna and both practical and reasonable specifications is in the neighborhood of  $\pm 0.25$  dB.

**NBSIR 74-387. Microwave measurement of coal layer thickness**, D. A. Ellerbruch and J. W. Adams, 33 pages (Sept. 1974). Order from NTIS as COM 74-11643.

Key words: automation; coal; coal mine safety; dielectric constant; energy; microwave measurement; nondestructive testing; thickness of coal layer.

The possibility of using a microwave system to measure coal layer thickness in a mine was investigated. Measurements were made in two different mines near Pittsburgh, Pa., and near Fairview, West Virginia. Frequencies in the range 0.5 GHz-4.0 GHz were used to measure samples between 10-40 cm thick. All samples were backed with a naturally-occurring draw slate.

The results indicated a definite possibility of determining layer thickness in most cases, although anomalies may introduce enough error to give misleading results in some cases. Anomaly detection may be very useful in some cases. More experimental data and theoretical study are needed for complete verification.

Data from a model and measured data show considerable agreement. The real value of this model is to point out causes and effects, and what additional information is needed in order to obtain a measurement system that is optimum under most conditions.

The dielectric constant of coal is apparently a function of moisture content. Draw slate seems to have a significantly higher dielectric constant than coal. Also, a layer of coal having different electrical characteristics within the layer was detected with the microwave system.

This technique has great potential if fully developed. It would have significant impact in areas of energy, safety, and productivity.

**NBSIR 74-388. Electromagnetic noise in Grace Mine**, J. W. Adams, W. D. Bensema, and M. Kanda, 138 pages (June 1974). Order from NTIS as COM 74-11687.

Key words: amplitude probability distribution; coal mine noise; digital data; electromagnetic interference; electromagnetic noise; electromagnetic pulse (chemical); emergency communications; Fast Fourier Transform; Gaussian distribution; impulsive noise; magnetic field strength; measurement instrumentation; spectral density; time-dependent spectral density.

Two different techniques were used to make measurements of the absolute value of electromagnetic noise in an operating hard-rock mine, Grace Mine, located near Morgantown, Pennsylvania. Diesel-powered haulage equipment is used in this mine, and the electromagnetic noise environment it creates was measured to see how it differs from the environment created by electric-powered haulage equipment. One technique measures noise over the entire electromagnetic spectrum of interest for brief time periods. It is recorded using broadband analog magnetic tape and the noise data is later transformed to give spectral plots. The other technique records noise amplitudes at several discrete frequencies for a sufficient amount of time to provide amplitude probability distributions.

The specific measured results are given in a number of spectral plots and amplitude probability distribution plots.

**NBSIR 74-389. Electromagnetic noise in McElroy Mine**, M. Kanda, J. W. Adams, and W. D. Bensema, 170 pages (June 1974). Order from NTIS as COM 74-11717.

Key words: amplitude probability distribution; coal mine noise; digital data; electromagnetic communications; electromagnetic interference; electromagnetic noise; Fast Fourier Transform; Gaussian distribution; impulsive noise; magnetic field strength; measurement instrumentation; spectral density; time-dependent spectral density.

Two different techniques were used to make measurements of the absolute value of electromagnetic noise in and above an operating coal mine, McElroy Mine, located near Moundsville, West Virginia. 300-volt-dc and 480-volt-ac machinery was measured to see the electromagnetic environment it created. One technique measures noise over the entire electromagnetic spec-



trum of interest for brief time periods. It is recorded using broadband analog magnetic tape and the noise data is later transformed to give spectral plots. The other technique records noise amplitudes at several discrete frequencies for a sufficient amount of time to provide amplitude probability distributions.

**NBSIR 74-390. Electromagnetic noise in Itmann Mine, W. D. Bensema, M. Kanda, and J. W. Adams, 113 pages (June 1974). Order from NTIS as COM 74-11718.**

**Key words:** amplitude probability distribution; coal mine noise, digital electromagnetic communications; electromagnetic interference; electromagnetic noise; Fast Fourier Transform; Gaussian distribution; impulsive noise; magnetic field strength; measurement instrumentation; spectral density; time-dependent spectral density.

Two different techniques were used to make measurements of the absolute value of electromagnetic noise in an operating coal mine, Itmann No. 3 Mine, located near Mullens, West Virginia. The electromagnetic environment created by 250-volt-dc and 550- and 950-volt-ac machinery in two longwall panels was measured and is reported. One technique measures noise over the entire electromagnetic spectrum of interest for brief time periods. It is recorded using broadband analog magnetic tape, and the noise data is later transformed to give spectral plots. The other technique records noise amplitudes at several discrete frequencies for a sufficient amount of time to provide amplitude probability distributions.

The specific, measured results are given in a number of spectral plots and amplitude probability distribution plots.

**NBSIR 74-396. Specification and measurement of frequency stability, J. H. Shoaf, 44 pages (Nov. 1974). Order from NTIS as COM 74-11766.**

**Key words:** Allan variance; frequency stability measurements; measurement system description; phase noise; spectral density; terminology standards.

This report gives concise definitions for specifying frequency stability for measurements in the frequency domain and time domain. Standards of terminology and of measurement techniques are recommended. Measurement systems are described in adequate detail so that the apparatus may be duplicated. Proposed extension of the measurement systems through 12.4 GHz is discussed.

**NBSIR 74-426. Survey plans and data collection and analysis methodologies: Results of a pre-survey for the magnitude and extent of the lead based paint hazard in housing, W. Hall, T. Ayers, and D. Doxey, 110 pages (Jan. 1974). Order from NTIS as COM 74-11074.**

**Key words:** housing; housing survey; lead; lead hazard; lead paint; lead poisoning; survey; urban health problems.

A pilot survey of housing in Washington, D.C. was carried out in order to develop and test methodologies, data collection procedures and formats that will be used in subsequent full scale surveys of cities to determine the magnitude and extent of the lead-based paint hazard in housing.

On site measurements of lead contents of interior and exterior surfaces were made (with portable x-ray fluorescence lead detectors, hereafter referred to as XRF's) on 115 dwelling units which were randomly selected from a Washington, D.C. city directory.

This report describes the procedures for identifying the survey sample, drawing the sample, and carrying out the survey. Computer programs for data handling and analysis are included and a brief summary of the data obtained from the pilot survey is presented.

**NBSIR 74-430. Chemical kinetics data survey VII. Tables of rate and photochemical data for modelling of the stratosphere**

**(revised), D. Garvin and R. F. Hampson, 104 pages (Jan. 1974). Supersedes NBSIR 73-203. Order from NTIS as COM 74-10724.**

**Key words:** atmospheric chemistry; chemical kinetics; data evaluation; energy transfer; gas phase; high temperature air chemistry; ion-molecule reactions; optical absorption cross sections; photochemistry; quantum yield; rate constants.

Chemical kinetic and photochemical data for gas phase reactions pertinent to the chemistry of the stratosphere are presented in four tables. These tables give recommended values and also cite recent experimental work. They give data in the following subject areas: chemical reactions and photochemistry of neutral species, energy transfer reactions, high temperature air reactions, and ion-molecule reactions.

**NBSIR 74-432. 1972 International Activities Center for Building Technology, C. C. Raley, 68 pages (Aug. 1973). Order from NTIS as COM 74-10751.**

**Key words:** cooperative programs; foreign visitors; information exchange; international building technology; international organization memberships; professional interaction.

This report summarizes the Center for Building Technology's 1972 international activities including formal cooperative programs, exchange programs, special projects, international organization memberships, foreign guests at CBT, and CBT foreign travel.

**NBSIR 74-434. Test and evaluation of baby walkers and walker-jumpers, D. J. Chwirut, 19 pages (May 1974). Order from NTIS as COM 74-11079.**

**Key words:** accident reports; baby walkers; infants; safety standards; test methods; walker-jumpers.

Accident reports from hospital emergency rooms were surveyed to determine the probable causes of accidents involving baby walkers and walker-jumpers. Test methods were developed to simulate service conditions to determine if the characteristics leading to accidents are present in all or only a few of the items on the market. These test methods include tests for dynamic and static stability, step roll-over stability, plastic bead strength, durability, and location of scissor joints. The test methods and performance criteria are intended to supply information leading to federal safety standards.

**NBSIR 74-438. Pilot demonstration of lead based paint hazard elimination methods, T. H. Boone, T. R. Ray, and W. G. Street, 26 pages (Dec. 1973). Order from NTIS as COM 74-10980.**

**Key words:** cost analysis; housing; lead based paint; lead poisoning; surface preparation; surface refinishing; water wash paint removal.

This report describes the removal of lead base paint from exterior surfaces of a single family attached house using alkaline/solvent thixotropic liquid paint removers followed by a high-pressure/low-volume water spray.

The extent of the reduction of the lead based paint hazard, the cost of the process and the observed problems and merits of this water wash paint removal system are presented.

**NBSIR 74-439. Preparation of reference materials for stationary source emission analysis: Beryllium, T. C. Rains, C. D. Olson, R. A. Velapoldi, S. A. Wicks, O. Menis, and J. K. Taylor, 12 pages (Mar. 1974). Order from NTIS as COM 74-10985.**

**Key words:** air pollution; atomic absorption spectrometry; beryllium; chemical analysis; fluorimetric analysis.

Techniques are described for the preparation of reference materials useful for evaluating the accuracy and precision of



analytical methods for measurement of beryllium emissions from stationary sources. These reference materials consist of membrane filters upon which are deposited microgram quantities of high-fired beryllium oxide and ampoules containing soluble beryllium and suspended beryllium oxide. Methods for measurement of the beryllium content of such materials by atomic absorption spectrometry and by spectrofluorimetry are described.

**NBSIR 74-442. High temperature slow crack growth in ceramic materials,** A. G. Evans, 48 pages (Feb. 1974). Order from NTIS as COM 74-10476.

Key words: ceramics; crack healing; crack propagation; cyclic fatigue; failure prediction; high temperature; static fatigue.

High temperature slow crack growth processes in several ceramic materials are examined under static and cyclic loading conditions. Data obtained at temperatures up to 1400 °C are used for purposes of failure prediction and for analysis of the slow crack growth phenomena. It is shown that purity plays a major role in slow crack growth resistance, particularly in the hot pressed materials, and that cycling in the low frequency regime does not significantly increase the rate of slow crack growth. The slow crack growth mechanisms appear to be primarily plasticity related. Two semi-quantitative mechanisms are presented, one due to dislocation motion and the other due to grain boundary sliding.

**NBSIR 74-443. Weight cleaning procedures,** H. E. Almer, 9 pages (Nov. 1973). Order from NTIS as COM 74-11003.

Key words: cleaning; standards; steam generator; storage; temperature equilibrium; weights.

Accurate and meaningful results in the calibration of weights depend on clean weights. This paper describes a method of cleaning weights.

**NBSIR 74-444. A review of natural stone preservation,** G. A. Sleater, 40 pages (Dec. 1973). Order from NTIS as COM 74-10548.

Key words: air pollution; historic structures; laboratory evaluation; natural weathering; stone decay; stone preservation.

With increased interest in stone preservation, it is desirable to know what causes stone to decay, and what materials can be used to preserve stone. This review covers the following topics: causes of stone decay, including faults in the stone, salts, natural weathering factors, air pollution, living organisms, and most importantly, water action; various materials that have been used to preserve stone, including paints, waxes, oils, inorganic chemical surface treatments and impregnants, silicones, siliconates, and synthetic organic polymers; methods of evaluating stone preservatives. Field and laboratory procedures for testing stone preservatives, the cleaning of stone, a glossary, and a bibliography are given in appendices.

**NBSIR 74-451. Field comparisons of steel surveyors' tapes,** C. L. Carroll, Jr., 16 pages (Nov. 1973). Order from NTIS as COM 74-11385.

Key words: graduation; length; scale; tape; temperature; tension.

Report describes a field procedure to compare a steel surveyor's tape to a standard tape that has been calibrated by the National Bureau of Standards. The procedure requires only a hand-held magnifier, two short scales, and two spring balances. Temperature reading device is not required since both tapes are made of steel and have the same temperature during the comparison.

**NBSIR 74-454. The equivalence of gravimetric and volumetric test measure calibration,** R. M. Schoonover, 16 pages (Feb. 1974). Order from NTIS as COM 47-10988.

Key words: check standard; closure; gravimetric calibration; standard deviation; test measure; volumetric transfer calibration.

This report discusses the statistical importance of observed differences between gravimetric and volume transfer calibrations of volumetric test measures. The data presented are results from the present NBS calibration program and conclusively show there are negligible differences between the two methods of calibration.

**NBSIR 74-455. Abstracts of papers on testing and analysis of flammable fabrics October 1972 to October 1973,** J. F. Krasny, 27 pages (Mar. 1974). Order from NTIS as COM 74-10865.

Key words: burn injuries; carpets; clothing; fabrics; fire retardants; flammability testing.

This collection of abstracts covers papers on textile flammability testing and analysis of flame retardant fibers and finishes, for the period October 1972 to October 1973. It is hoped that this collection will facilitate research in this area in which there has been great interest in connection with the introduction of fabric and garment flammability standards by the Federal and several state governments. Similar collections appear in the Proceedings of the Annual Meetings of the Information Council on Fabric Flammability, available from the Council, Room 510, 1457 Broadway, New York, N.Y. 10036.

**NBSIR 74-456. Evaluation of the fire performance of a dibromotetrafluoroethane—blown rigid polyurethane foam,** T. G. Lee, W. J. Parker, and M. Tryon, 17 pages (Apr. 1974). Order from NTIS as COM 74-11793.

Key words: dibromotetrafluoroethane; fire tests; flame spread index; heat release rate; ignition temperature; rigid urethane foam; smoke.

The fire performance characteristics of a dibromotetrafluoroethane—blown rigid polyurethane foam were measured by several laboratory test methods. Measurements included: surface flammability, smoke and gases generated at elevated temperature and during combustion, ignition temperature, rate of heat release, and fire growth. The maximum concentration of the blowing agent in the specimen was approximately 13 Wt%. Specimen density was 0.046 g/cm<sup>3</sup>. As a function of temperature, release of blowing agent from collapsed cells began at about 60 °C and became considerable at 135 °C. The material had a flame spread index (ASTM E-162) of 11 with smoke levels of 170 and 480 (maximum specific optical density) under non-flaming and flaming exposures, respectively. The measured rate of heat release was 8.8 W/cm<sup>2</sup>, about 5 times that of a fibrous glass insulation. The measured flash ignition temperature was 530 °C for the material.

**NBSIR 74-457. Transmission of electrons through foils,** S. M. Seltzer, 84 pages (Apr. 1974). Order from NTIS as COM 74-11792.

Key words: angular distribution; electrons; energy spectra; reflection; transmission; transport calculation.

The transmission of electrons through foils has been studied by a Monte Carlo method. Cases involving electrons with energies from 50 keV to 1 MeV normally incident on beryllium, mylar, aluminum, and titanium foils are considered. Good agreement with experimental results has been found for quantities such as the number transmission, the energy and angular distribution of the emergent electrons, and the spatial distribution of energy deposited in the foil.



A comprehensive set of results has been generated for 100, 150, 200, 300 and 400-keV electrons incident on beryllium, mylar, aluminum, and titanium foils that are commonly used as vacuum windows in conjunction with low energy electron accelerators. Quantities given are the electron number and energy transmission and reflection, the energy absorbed, and the energy and angular distribution of the transmitted electrons. It is shown that much of the results can be presented in a scaled form which reduces the explicit dependence on, and facilitates the interpolation with respect to, the incident energy.

**NBSIR 74-458. Laser damage in materials,** A. Feldman, D. Horowitz, and R. M. Waxler, 16 pages (Mar. 1974). Order from NTIS as AD 776-337.

Key words: absorption coefficient; damage threshold; electrostriction; inclusion damage; intrinsic damage; Kerr effect; laser damage; laser glasses; laser rod materials; modulator crystals; nonlinear index of refraction; optical glasses; polarizer materials; self-focusing.

This report summarizes the study of damage and self-focusing in materials used in Q-switch solid-state laser systems. In borosilicate crown glass, fused silica, dense flint glass, and yttrium aluminum garnet, self-focusing appears to be the main cause of damage. An analysis of damage threshold measurements with linearly polarized radiation suggests that the Kerr effect is the dominant self-focusing mechanism with a significant contribution to self-focusing from the thermal effect. The electrostrictive effect is negligible. The damage threshold in Nd:doped laser glasses appears to be intrinsic. In all the above materials, the damage threshold for circular polarization is greater than the damage threshold for linear polarization. In lithium niobate, calcite, potassium dihydrogen phosphate, and deuterated dihydrogen phosphate, damage at the lowest levels is caused by inclusions. Bulk and surface damage thresholds in Nd:doped thoria:yttrium oxide ceramic are obtained relative to bulk damage thresholds in several optical materials. Relationships under different geometric boundary conditions are also derived for solid materials between the stress-optic coefficients and the electrostrictive coefficients.

**NBSIR 74-464. The Shirley Highway Express-Bus-On-Freeway Demonstration Project—second year results,** J. T. McQueen, R. F. Yates, and G. K. Miller, 87 pages (Nov. 1973). Order from NTIS as COM 74-10785.

Key words: bus transit; busway operations; commuter travel behavior; express bus-on-freeway operations; project evaluation; transit operations.

This report contains: (a) A review of the performance of the Shirley Highway Express-Bus-On-Freeway Demonstration Project between 1969 and 1973; (b) A description of the methodology and data use to estimate project measures of effectiveness; (c) A discussion of factors considered in commuter mode choice decision making.

**NBSIR 74-465. Shear and tension-bending fatigue test methods for threaded airframe fasteners,** D. J. Chwirut, D. E. Marlowe, and J. S. Steel, 56 pages (Sept. 1974). Order from NTIS as COM 75-10417.

Key words: airframe fastener; double shear; fatigue; single shear; tension-bending; test methods.

Fatigue test methods for threaded airframe fasteners loaded in other than direct tension are described. The types of loading considered are single shear, double shear, and tension-bending. The test fixtures used in these tests are described. Results of tests on lots of fasteners from different manufacturers indicate that fasteners considered identical on the basis of direct tension procurement tests exhibit different fatigue life characteristics when loaded in shear and/or tension-bending. Thus the test

methods described herein may be of future value as procurement tests for airframe fasteners.

**NBSIR 74-466. Management of data elements in information processing,** H. E. McEwen, Ed., (Proceedings of a Symposium Sponsored by the American National Standards Institute and by The National Bureau of Standards, held at NBS, Gaithersburg, Maryland, Jan. 24-25, 1974), 490 pages (Apr. 1974). Order from NTIS as COM 74-10700.

Key words: American National Standards; American National Standards Institute; data; data base systems; data elements; data management; data processing; Federal Information Processing Standards; information interchange; information processing; information systems.

Recent technological advances in computers and communications make possible the integration of data systems and the exchange of data among them on an expanding scale. However, the full effect of these advances cannot be realized unless the need for uniform understanding of the common information (data elements) and their expression in data systems is recognized and a means provided to effectively manage this information. The increasing interrelationships among the data systems of Federal, State, and local governments, and with industry and the public add emphasis and dimension to the need for the improved management of data elements in information processing.

These Proceedings are for the first Symposium on the Management of Data Elements in Information Processing held at the National Bureau of Standards on 1974 January 24 and 25. Over 400 representatives of Federal and State governments, industry and universities from 30 states, from Canada, and Sweden were in attendance. Thirty-four speakers discussed data element management in the fields of health care, water resources, state government information systems, transportation, libraries, market research, manufacturing, banking, information retrieval systems, military systems, computer programming and software systems, and motor vehicle registration.

**NBSIR 74-467. Simulated solar heat tests on M.U.S.T. air-inflatable, double-wall hospital ward shelters,** L. W. Masters, J. W. Grimes, and R. A. Crist, 64 pages (May 1974). Order from NTIS as COM 74-11754.

Key words: adhesives; air-inflatable shelter sections; cloth webs; polyester and nylon fabrics; sewn seams; sewn seam strapping; solar heat load; test procedure.

At the request of the United States Army Natick Laboratories (USANLABS), the Center for Building Technology conducted solar heat load tests on five sections of M.U.S.T. air-inflatable, double-wall hospital ward shelters. The purpose of the tests was to evaluate the effect of solar heat load, as simulated by infrared heat lamps, on various materials and construction designs proposed for use in shelters.

**NBSIR 74-470. Interaction of plasma proteins with surfaces,** C. A. Fenstermaker, W. H. Grant, B. W. Morrissey, L. E. Smith, and R. R. Stromberg, 83 pages (Mar. 22, 1974). Order from NTIS as COM 74-10984.

Key words: adsorption; blood protein; bound fraction; ellipsometry; polymer adsorption; protein adsorption.

The interaction of blood proteins with surfaces has been investigated with principal attention focused on those proteins that are either major constituents of blood plasma or are implicated as being important in the clotting process. Emphasis has been placed on molecular conformational changes occurring upon the interaction of such proteins with surfaces. The extension of adsorbed molecules of fibrinogen, albumin, and prothrombin on a number of selected materials was studied by ellipsometry. The results indicate a dependence of conformation on surface energy.



Measurements of the bound fraction (number of carbonyl surface attachments) of these adsorbed blood proteins on a silica surface showed that approximately ten percent of the carbonyl groups were attached to the surface for prothrombin and serum albumin at all values of surface population for the solution concentrations studied. Competitive interactions of prothrombin and fibrinogen during the process of adsorption, displacement, and desorption have been measured and rates of adsorption of albumin were measured on chrome and silica surfaces.

**NBSIR 74-471. Life cycle costing of police patrol cars: Summary report,** R. T. Ruegg, 23 pages (Mar. 1974). Order from NTIS as COM 74-10981.

**Key words:** fleet management; life cycle costing; patrol cars; police fleets; vehicle leasing; vehicle management.

There are many different choices to be made with respect to police vehicle acquisition, utilization, maintenance, and disposition. Cost comparisons among the different alternatives are an important element in the choices to be made. To make valid cost comparisons, it is necessary to employ the techniques of life-cycle costing. This means the inclusion of all relevant costs and the conversion of costs to an equivalent basis to take into account differences in the timing of expenditures.

This report briefly summarizes the results of a larger study which compares the life cycle costs of some of the alternatives associated with police fleet management. The full report from which this report is derived is entitled *Life Cycle Costing: Efficiency in Vehicle Acquisition, Operation, and Disposition*.

The focus of the study is on police patrol cars, but the methods are applicable to other types of vehicles. Specific topics addressed by the larger study and summarized here are the cost effects of purchasing different sizes of patrol cars and different optional equipment, the advantages and disadvantages of direct ownership of vehicles as compared with leasing, the costs of contracting out maintenance as compared with self-maintenance of vehicles, the cost effects of alternative utilization practices, the optimal timing of vehicle replacement, and the comparative efficiency of different methods of vehicle disposition.

**NBSIR 74-473. Natural disasters: Some empirical and economic considerations,** G. T. Sav, 72 pages (Feb. 1974). Order from NTIS as COM 74-11719.

**Key words:** benefit-cost analysis; disaster mitigation; earthquakes; economics; efficient; floods; hurricanes; natural disasters; optimal; tornadoes; total cost minimization.

This study examines the extent of some of the losses resulting from natural disasters. An estimate of these losses is necessary in order to determine the potential benefits that might be realized from mitigating the negative economic impacts from natural disasters. Absolute and relative losses resulting from hurricanes, floods, earthquakes, and tornadoes are examined. This data will help individuals, communities, and the Federal government make better decisions as to how and what extent protection against disasters should be provided. The application of benefit-cost analysis for choosing the optimal level of protection against disasters is also discussed. Recommendations are made for further research in determining the economic feasibility of various techniques designed to mitigate the losses from disasters.

**NBSIR 74-474. Metallurgical analysis of wear particles and wearing surfaces,** A. W. Ruff, 59 pages (Apr. 1974). Order from NTIS as AD 778340.

**Key words:** bearings; electron diffraction; electron microscopy; gears; lubrication; particles; wear.

Results are presented from a program involved in characterizing the wear particles and surface degradation produced by wear in bearing and gear tests in which the effects of several variables

on failure of the wearing surfaces has been examined. The information obtained has been correlated with the results of allied studies conducted by others in an attempt to develop an understanding of the processes producing wear and degradation of metal surfaces in sliding, rubbing, rolling, and/or rotating contact and the effects of lubricants, lubricant additives, bearing materials, etc. on these processes. The characterization of the wear particles and wearing surfaces should aid in the establishment of the interrelationships between wear particle shape, size, size distribution, chemical compositions, metallurgical structure, and surface damage prior to failure.

**NBSIR 74-477. Performance characteristics of a "bulk effect" humidity sensor,** J. W. Little, S. Hasegawa, and L. Greenspan, 33 pages (May 1974). Order from NTIS as COM 74-11784.

**Key words:** "Brady Array" sensors; electric hygrometer; humidity; humidity sensor; moisture measurement; relative humidity; water vapor measurement.

A laboratory study was made of the performance of "Brady Array" humidity sensors over a range of ambient temperatures from - 40 °C to + 20 °C encompassing relative humidities from 0 to 90 percent. Information was obtained on such characteristics as sensitivity, hysteresis, temperature effect, short-term and long-term repeatability.

**NBSIR 74-479. Analysis of cost-sharing programs for pollution abatement of municipal wastewater,** H. E. Marshall and R. T. Ruegg, 145 pages (Sept. 1974) Order from NTIS as COM 74-11769.

**Key words:** cost sharing; efficiency; equity; financing; non-plant treatment; sewage treatment, user fees; water pollution.

This study evaluates existing cost-sharing programs for wastewater pollution abatement as described in the Federal Water Pollution Control Act Amendments of 1972, describes alternative cost-sharing programs that provide improvements in terms of national efficiency and equity criteria as defined herein, and suggests related areas for further research. Emphasis is on how Federal cost sharing biases communities in favor of certain kinds of techniques. The approach is to describe the current cost-sharing programs for both plant and nonplant techniques; to examine cost-sharing, legal, and other institutional biases against certain techniques; to analyze efficiency and equity effects of alternative cost-sharing programs; and to describe the incentive effects of cost-sharing on nonfederal interests with respect to their choices among abatement techniques. Findings of the study are that more efficient abatement will result if the *same* percentage cost share applies to all plant and nonplant techniques of abatement; the *same* percentage also applies to all categories of cost (e.g., capital, land, operation and maintenance) for a given technique; the *same* percentage applies to large and small communities; institutional constraints on the selection of nonplant techniques are removed; and if the program provides for Federal cost sharing of every abatement technique that is technically viable.

**NBSIR 74-481. Absolute calibration of vibration standards by the three-mass reciprocity method,** J. D. Ramboz, 50 pages (Apr. 1974). Order from NTIS as COM 74-11794.

**Key words:** absolute calibration; accelerometers; calibration; reciprocity calibration; vibration exciters; vibration pickups; vibration standards.

Reciprocity calibration of electrodynamic vibration exciters is reviewed. A new method is proposed. The theory for the new Three-Mass reciprocity calibration method is developed. The process requires that the electrical impedance of the exciter's drive coil be measured for three added masses separately mounted on the exciter's armature. The sensitivity of the accelerometer mounted in the armature is solved in terms of a



change of electrical impedance for a change of mass, voltage ratio, electrical resistance, and frequency. A set of 38 measurements were made at 1000 Hz to experimentally verify the theory. The value of sensitivity was  $2.070 \text{ pC/g} \pm 1.3 \text{ percent}$ . This agreed to within about  $\pm 0.65 \text{ percent}$  of a transfer calibration from Bouche-Levy calibrated standards and the manufacturer's estimated value. Measurements were made to verify the theory; improvement to an uncertainty of about  $\pm 0.2 \text{ percent}$  is ultimately possible in the absolute calibration using this method.

**NBSIR 74-485. Strength of glass—a fracture mechanics approach**, S. M. Wiederhorn, 24 pages (May 1974). Order from NTIS as AD 780704.

Key words: crack growth; fracture; glass; static fatigue; strength.

After a brief review of those factors that determine the strength of glass (brittleness, surface flaws, susceptibility to stress corrosion cracking), a discussion will be given of how fracture mechanics techniques can be used to understand the physics and chemistry of glass strength. In this paper we assume that the strength of glass is limited by the growth of cracks that are always present in normal glass surfaces. Fracture mechanics techniques can be used to characterize the crack growth and to relate the growth to experimental parameters such as temperature, environment, and glass composition. Crack growth data obtained in this manner can be used to develop a deeper understanding of fracture mechanisms, and to develop charts that can be used for the design of glass structural components. Examples of both applications are given in the paper.

**NBSIR 74-486. Reliability, life prediction and proof testing of ceramics**, S. M. Wiederhorn, 62 pages (May 1974). Order from NTIS as AD 780705.

Key words: ceramics; crack propagation; delayed failure; fracture; proof testing; Weibull analysis.

A critical review is presented of the use of proof testing as a design method for assuring the reliability of structural components. The advantage of proof testing over the statistical approach used for design lies in the insensitivity of the proof testing method to the detailed history of handling or processing of structural components. Methods are presented for developing and using proof test diagrams to assure component lifetime after proof testing. Procedures of proof testing and precautions that must be followed during proof testing are discussed. Provided these precautions are followed, proof testing offers a general method for assuring the reliability of structural components under stress.

**NBSIR 74-487. Proposed revision of American National Standard COBOL**, R. E. Rountree, Jr., Ed., 544 pages (Jan. 1974). Order from NTIS as COM 74-10886.

Key words: COBOL; data processing; Federal Information Processing Standard; information interchange; information processing; programming language; software.

This document is for review purpose only in anticipation of its becoming an American National Standard and subsequent adoption as a Federal Information Processing Standard. The American National Standard COBOL defines the elements of the COBOL programming language and the rules for their use. The standard is used by implementors as the reference authority in developing compilers and by users for writing programs in COBOL. The primary purpose of the standard is to promote a high degree of interchangeability of programs for use on a variety of automatic data processing systems.

**NBSIR 74-495. Development of a radiant panel test for flooring materials**, L. G. Hartzell, 79 pages (May 1974). Order from NTIS as COM 74-11575.

Key words: carpet; fire test; flammability; flooring; heat flux; ignition; radiant panel.

This paper summarizes the work of a year long program to continue the development of a radiant panel type test for flooring materials, the original concept of which was developed at the Armstrong Cork Company's Research and Development Center in Lancaster, Pennsylvania. This program at the National Bureau of Standards had as its goal, the further development of the test for possible adoption as a standard ASTM test method.

The program work was divided into five phases. During the first phase, an attempt was made to duplicate the performance of the original apparatus in a similar one at the National Bureau of Standards Laboratory. The proof of this duplication was shown in replicate testing using a wide range of flooring on both apparatus.

In the second phase of the program, a new set of test conditions were found in an attempt to eliminate some of the more serious equipment and procedural problems of the test. These new conditions provided the test with the ability to rate flooring materials according to their ability to resist the surface spread flames.

Under the third and fourth phases of the program, the effects of changes in some test parameters was investigated and other test characteristics were measured. Phase V, the data analysis and report, concluded the program.

**NBSIR 74-496. Standard measurements of the resistivity of silicon by the four-probe method**, W. M. Bullis, 75 pages (Aug. 1974). Order from NTIS as COM 74-11576.

Key words: ASTM Committee F-1; electronics; four-probe method; resistivity; semiconductors; silicon.

An improved standard procedure for measurement of circular silicon slices with four in-line point probes has been developed in cooperation with the Resistivity Task Force of ASTM Committee F-1. Detailed analysis of a series of round-robin experiments showed that the procedure can attain a precision of  $\pm 2 \text{ percent}$  (three standard deviations) for interlaboratory comparisons of slices with room temperature resistivity between 0.005 and 120 ohm-cm. Resistivity nonuniformity in the test slices was shown to be a significant factor in limiting the precision which could be achieved. The importance of including correction factors for temperature, finite thickness, finite diameter, and unequal probe separations was demonstrated. The results of the round-robin experiments also emphasized that the precision quoted can only be achieved if the measurements are carefully and correctly made on a well maintained, accurately calibrated test system which meets the requirements imposed by the test method. Determination of the precision to be expected from the method in nonreferee applications such as routine production and quality control will require additional study of such factors as surface conditions, probe force, current levels, etc. Nevertheless, use of the various procedures of the method, in particular the sections on probe and measuring circuit evaluations and on thermal sinking of the wafer, would be expected to yield significantly improved precision in such applications. Use of these procedures on a regular and widespread basis should be encouraged.

**NBSIR 74-497. US/UK joint complementary research program in building, (wind loads, water supply, fire detection), July 1972-June 1973**, C. C. Raley, I. A. Benjamin, R. D. Marshall, and J. E. Snell, 24 pages (Oct. 1973). Order from NTIS as COM 74-11269.

Key words: cooperative programs; fire safety; hydraulics; international building technology; wind loads.

This is a status report of the progress achieved under the



"Joint Complementary Research Program" sponsored by the Building Research Establishment (UK) and the Center for Building Technology (US), during the period July 1972 through June 1973. The program includes three projects: Wind Loads on Buildings, Design of Water Supply and Drainage Installations in Buildings, and Fire Detection in Buildings, each of which is discussed in the report.

**NBSIR 74-499. An analysis of the aging of paper: Possible reactions and their effects on measurable properties**, W. K. Wilson and E. J. Parks, 37 pages (Apr. 26, 1974). Order from NTIS as COM 74-11378.

Key words: accelerated aging; aging; aging of cellulose; aging of paper; cellulose; cellulose aging; natural aging; paper; paper aging; tests for paper.

Various reactions that cellulose can undergo are reviewed in relation to their bearing on the aging of paper. The principal reactions of cellulose are hydrolysis, oxidation, crosslinking, change in lateral order in the bonding area, and, during accelerated aging, thermal decomposition. The effects these various reactions might have on tests that are available for evaluating changes that occur during the aging of paper are reviewed. Some special examples of these reactions that occur during natural aging, because of special composition characteristics of the paper, are discussed. Suggestions are made concerning most sensitive tests for use in detecting changes in paper and tests, regardless of sensitivity, available for determining *what* happens during aging. Some general guidelines regarding specifications for permanent record papers are discussed.

**NBSIR 74-506. Development of a national anthropometric data base: A preliminary study report**, H. L. Steinberg, 85 pages (June 1974). Order from NTIS as COM 74-11632.

Key words: anthropometric survey; biostereometric body-dimensions; National Data Base.

A study was made to determine the need for development of a Nationally Representative Anthropometric data base. Potential users and their needs are identified and the inability of existing anthropometric data to satisfactorily meet these needs is established. Three scenarios for developing a useful data base are considered. Two involve the use of biostereometrics while the third takes a relatively conventional approach to obtaining body dimensions. Conclusions relevant to each of these scenarios, as well as the potential advantages/disadvantages of each, are developed. Salient conclusions common to all three scenarios include: The need for a (R & D type) pilot study; the desirability of linking the actual anthropometric survey to a National Center for Health Statistics (NCHS) "Health and Nutrition Examination Survey" (HANES); and a data base development time of at least 7 years. Program costs, detailed in an appendix, ranged from \$2.4M to \$5.2M. Mechanisms for administering and funding this survey were considered briefly. An estimation of the optimal sampling dimensions for the proposed survey, based on clothing industry needs, is given.

**NBSIR 74-509. Strength and stability testing of high chairs**, D. J. Chwirut, 17 pages (June 1974). Order from NTIS as COM 74-11377.

Key words: accident reports; high chairs; infants; safety standards; stability and strength; test methods.

Accident reports from hospital emergency rooms were surveyed to determine the probable causes of accidents involving high chairs. Possible test methods for determining the characteristics of the high chairs leading to the accidents were investigated, including the test methods recommended in the Juvenile Products Manufacturers Association Voluntary Safety Standard for High Chairs. These tests included tests for tray strength, chair static strength, foot rest strength, restraining strap

strength, and stability. These test methods and performance characteristics are intended to supply information leading to federal safety standards.

**NBSIR 74-510. Effect of phase separation on the physical and chemical properties of glasses-density and chemical durability**, J. H. Simmons, S. A. Mills, and B. F. Howell, 33 pages (July 1974). Order from NTIS as AD 782793.

Key words: borosilicate glass; chemical durability; density; immiscibility.

This report covers results from density and chemical durability measurements on a borosilicate glass widely used commercially for chemical glassware while the glass undergoes liquid-liquid immiscibility. A net decrease in density is observed during an isothermal heat-treatment below the transition temperature. This density or molar volume change is related to the effect of pressure on the phase transition temperature by means of equations derived herein. The chemical durability of the material is measured following the ASTM titration technique and shows a large degradation of chemical resistance to attack by water as a result of sub-immiscibility structure development. The effect is analyzed in terms of the change in composition of the phases associated with the immiscibility transition.

**NBSIR 74-511. Fire research publications, 1973**, N. H. Jason, 13 pages (June 1974). Order from NTIS as COM 74-11448.

Key words: bibliographies; building fires; construction materials; fire departments; fire tests; flame spread test; flammability tests; flammable fabrics; Operation BREAKTHROUGH; protective clothing.

A list of publications is provided representing the papers and journal articles prepared by members of the Programmatic Center for Fire Research (PCFR) and by NBS personnel under contract to PCFR and by external laboratories under contract to the PCFR during 1973.

**NBSIR 74-515. Report of conference on making service industries more productive through computers and automation**, A. K. McAdams and M. M. Henderson, 176 pages (June 1974). Order from NTIS as COM 74-11498.

Key words: automation; computers; productivity; service industries.

The Engineering Foundation and the National Bureau of Standards, Institute for Computer Sciences and Technology, cosponsored this conference to bring together persons actively concerned with the subject to identify gaps in knowledge, needs and opportunities in the area, and to point up governmental goals and programs to respond to such needs. This report contains the principal presentations and the texts of Workshop Panel reports prepared during the conference.

**NBSIR 74-516. Chemical kinetics data survey VIII. Rate constants of ClO<sub>x</sub> of atmospheric interest**, R. T. Watson, 51 pages (June 1974). Order from NTIS as COM 74-11384.

Key words: absorption cross sections; atmospheric chemistry; chemical kinetics; chlorine; chlorine dioxide; chlorine monoxide; data evaluation; gas phase; optical; rate constants; stratospheric chemistry.

The quantitative data on reactions of chlorine atoms and the chlorine oxides are compiled. Preferred values for rate constants are given where possible. Optical absorption cross sections are given for the species that may photolyze in the atmosphere. The experimental techniques used to obtain the rate data are discussed.

**NBSIR 74-519. Photometric tests of vehicle glazing materials**, W.



A. Hall, E. L. Walters, I. Nimeroff, and C. A. Douglas, 33 pages (Nov. 1974). Order from NTIS as PB 238284.

Key words: automobile paint colors; automobile windshield color; photometric tests; spectral reflectance; spectral transmittance; transmittance variation; vehicle glazing materials.

Measurements were made on the spectral transmittance of representative vehicle glazing materials and spectral reflectance of representative automobile paints. Colorimetric data were derived from these spectral measurements.

By varying the instrumental parameters of the in-laboratory procedure described in NBS Report No. 10902 for measuring the transmittance of glazing materials, errors in transmittance were obtained and were evaluated. The standard deviation of the transmittance measurements was less than 0.01 except at incidence angles of  $70^\circ$  where it was about 0.02.

**NBSIR 74-520. Evaluation of structural properties of masonry in existing buildings**, S. G. Fattal and L. E. Cattaneo, 127 pages (July 1974). Order from NTIS as COM 74-11480.

Key words: analysis; compressive strength; deflection; design; flexural strength; masonry walls; racking strength; seismic loading; shear strength; shear wall; stiffness.

The current state of knowledge on the structural behavior of masonry is synthesized to develop a methodology for the evaluation of the load capacity of masonry walls in existing buildings. A procedure is described for direct sampling and testing of specimens removed from masonry walls of buildings to determine their strength in shear, flexure and compression, and to measure their load-deformation characteristics. A documentation of strength and stiffness properties obtained from available test data is included to provide an alternate source of information on masonry of comparable construction. Sample calculations of masonry building analysis for seismic forces are given in Appendices A and B.

**NBSIR 74-524. Practicality of diversion path analysis**, W. M. Murphey and J. C. Schleter, 36 pages (July 1974). Order from NTIS as COM 74-11568.

Key words: analysis; diversion of nuclear materials; diversion path analysis; internal control system characterization; nuclear material safeguards; safeguards.

One can define the safeguards system for nuclear material as the set of all protective actions taken to prevent or to deter attempts to divert nuclear material to unauthorized use. Maintenance of effective safeguards requires a program for routine assessment of plant safeguards systems in terms of their capabilities to satisfy safeguards aims. Plant internal control systems provide capabilities for detection of unprevented diversion and can provide assurance that diversion has not occurred. A procedure called Diversion Path Analysis (DPA) enables routine assessment of the capabilities of internal control systems in this regard and identification of safeguards problem areas in a plant. A framework for safeguards system design is also provided which will allow flexibility to accommodate individual plant circumstances while maintaining acceptable diversion detection capability. The steps of the procedure are described and the practicality of the analytical method is shown by referring to a demonstration test for a high throughput process where plant personnel were major participants. The boundary conditions for the demonstration case are given, along with some conclusions about the general procedure.

**NBSIR 74-525. Optical materials characterization**, A. Feldman, D. Horowitz, R. M. Waxler, I. Malitson, and M. J. Dodge, 20 pages (July 1974). Order from NTIS as AD 782564.

Key words:  $As_2S_3$ ; chalcogenide glass; coefficient of thermal expansion; elastic constants; infrared laser window

materials; KCl; photoelasticity; polycrystalline ZnSe; refractive index; stress-optical constants; thermal coefficient of refractive index.

A program has been established for measuring refractive index,  $n$ , stress-optical constants,  $q_{ij}$ , change of index with temperature,  $dn/dT$ , thermal expansion coefficient,  $\alpha$ , and elastic compliances,  $s_{ij}$ , of infrared laser window materials. These parameters are necessary for determining the optical distortion that occurs in windows due to heating by the absorption of high power laser radiation.  $n$  and  $dn/dT$  are measured over a spectral range 0.2 to  $50\ \mu m$  by the method of minimum deviation on precision spectrometers. Twyman-Green and Fizeau interferometers which operate at  $0.6328\ \mu m$ ,  $1.15\ \mu m$ , and  $10.6\ \mu m$ , are used for measuring  $q_{ij}$ ,  $\alpha$ ,  $dn/dT$  and  $s_{ij}$ . Materials currently under study are polycrystalline ZnSe,  $As_2S_3$  glass, chalcogenide glass (Ge 33%, As 12%, Se 55%), and KCl. Results are given for  $n$  and  $dn/dT$  in KCl, and  $q_{ij}$  and  $s_{12}$  in ZnSe,  $As_2S_3$  glass, and chalcogenide glass.

**NBSIR 74-527. Development of solid state samplers for work atmospheres**, B. Greifer, B. C. Cadoff, J. Wing, and J. K. Taylor, 54 pages (June 1974). Order from NTIS as COM 74-11720.

Key words: air analysis; air sampler; charcoal; chlorine; fluorine; gas analysis; hydrogen cyanide; hydrogen fluoride; industrial hygiene; phosphine; sodium acetate; sorber, solid; work atmosphere.

A program is described for evaluating the efficiency of solid sorbers for collecting trace quantities of hydrogen fluoride, phosphine, hydrogen cyanide, chlorine, and fluorine in work atmospheres for subsequent laboratory analysis. The gas handling and sampling instrumentation is described, and experimental results to date are presented.

Sodium acetate is a very efficient sorber for hydrogen fluoride, and its solubility in water proves to be highly advantageous for subsequent HF determination by ion selective electrode. Potassium permanganate impregnated silica gel sorbs phosphine effectively, and Ascarite has been found to sorb hydrogen cyanide, but quantitative experiments on the latter two systems are still in progress.

Work on chlorine and fluorine systems will be initiated in the near future.

**NBSIR 74-529. Project plans fiscal year 1974**, J. J. Diamond, 72 pages (July 1973). Order from NTIS as COM 74-11495.

Key words: anthropometry; communications equipment; forensic science; Law Enforcement Standards Laboratory; LESL; performance standards; project plans; protective equipment; security equipment; standards; warning lights and sirens.

Plans are presented for nineteen projects approved and funded for FY-74. They include plans for the preparation of performance standards, user guidelines and reports on law enforcement equipment in the communications, security, protective equipment, investigative aid, emergency equipment and clothing areas.

**NBSIR 74-533. Influence of windshield tint on the temperature in automobile passenger compartments**, W. S. Hurst and M. G. Scroger, 113 pages (Sept. 1974). Order from NTIS as PB 238573.

Key words: automobile compartment temperatures; automobile windshields; glazing materials; transmittance of vehicle glazing materials.

The effect of tinting in the glass of windshields on the air temperature in automobile passenger compartments was investigated. Measurements were performed with two nearly identical vehicles, one equipped with tinted windshield glass and



one equipped with clear windshield glass. All other glass in both vehicles was tinted. Tests were performed statically, with the cars parked facing south, and dynamically, with the cars driven at approximately 80 km/h. In the static tests, the interior air temperatures as determined by liquid-in-glass thermometers were typically 2 to 3 °C cooler in the vehicle with the tinted windshield. In the dynamic tests, the differences in the interior air temperatures were smaller, typically about 0.5 to 1.5 °C. The interior air temperature differences determined with thermocouples varied with the thermocouple position. The differences typically ranged from a negligible amount (less than 1 °C) to about 6 °C; temperature differences as large as 16 °C were observed on the car dash.

**NBSIR 74-535. A selected and annotated bibliography of compilations of data relevant to biochemical thermodynamics**, G. T. Armstrong, G. R. Janes, and R. N. Goldberg, 81 pages (July 1974). Order from NTIS as COM 74-11659.

**Key words:** bibliography; biochemistry; biology; data compilations; thermochemistry; thermodynamics.

This report is a selected and annotated bibliography of sources of data compilations relevant to biochemical thermodynamics. Included in the annotations are brief descriptions of the type of thermodynamic properties tabulated, the class of materials dealt with, and the degree of completeness of the compilations.

**NBSIR 74-537. CODATA guidelines on reporting data for chemical kinetics**, 18 pages (Aug. 1974). Order from NTIS as COM 74-11577.

**Key words:** chemical kinetics; guidelines; recommended procedures for reporting data; standardization; units.

This document is a copy of the report, June 1974, of the Task Group on Data for Chemical Kinetics of the Committee on Data for Science and Technology (CODATA). In this report recommendations are made about the reporting of experimental chemical kinetics data.

**NBSIR 74-539. Energy conservation at the NBS laboratories**, J. D. Hoffman, 81 pages (July 1974). Order from NTIS as COM 74-11574.

**Key words:** contingency plans; electricity; energy conservation; heating fuels; humidity control; transportation.

An Energy Task Force was established at NBS to effect energy conservation, to develop contingency plans to keep the Laboratories functioning in the event of reduced energy supply and to assist employees with transportation problems. The NBS Laboratories use a total of ~ 115 million kWh of electricity and ~ 780 billion BTU of heating fuel annually to power equipment and to provide a reliable environment. The Task Force conducted a systems analysis of energy use and found that 85 percent of the energy is used in climate control. A mathematical model for the climate control system was developed that affords an accurate comparison between observed and calculated energy use. As part of the analysis of energy use, conservation measures were identified and implemented. These measures include lighting reductions, building and zone shut-downs, thermostat adjustments, and changes in cooling coil control parameters. The conservation actions resulted in a reduction of ~ 12 percent in electricity and ~ 18 percent in heating fuel. The Task Force formulated contingency plans to reduce energy use on short notice in preparation to respond to area-wide energy problems. These plans provide for a set of priorities to produce a reduction of 2-5 megawatts in electrical demand and for an effective doubling in oil storage capacity. Task Force recommendations address all phases of energy use and implementation of them will increase electricity conservation to ~ 15 percent and heating fuel conservation to ~ 21 percent.

**NBSIR 74-543. High temperature MHD materials**, S. J. Schneider, W. Capps, H. P. R. Frederikse, W. R. Hosler, D. A. Kauffman, E. M. Levin, C. L. McDaniel, T. Negas, and E. R. Plante, 129 pages (Aug. 1974). Order from NTIS as COM 74-11772.

**Key words:** coal slag; electrical conductivity (MHD); electrodes; insulators; MHD; MHD materials; MHD materials testing; phase equilibria (MHD); vaporization (MHD); viscosity (MHD).

Under the auspices of the Office of Coal Research the National Bureau of Standards has underway a program of materials research appropriate to magnetohydrodynamics (MHD). The overall objective of the work is to provide materials property information necessary for the design, construction, and operation of an open cycle, coal fired MHD electric generation plant. The program consists of several interrelated investigations in the areas of phase equilibria, electrical properties, vaporization, viscosity and materials testing. Initial work has centered on the behavior of coal slag but also encompasses the physical and chemical characteristics of other MHD process contaminants (alkali seed) and important electrode and insulator materials. The report summarizes the important technical results obtained during the period July 1, 1972-June 30, 1974 under the combined NBS-OCR program.

**NBSIR 74-544. Kerr coefficients of nitrobenzene and water**, R. E. Hebner, Jr., R. J. Sojka, and E. C. Cassidy, 35 pages (Aug. 7, 1974). Order from NTIS as COM 74-11525.

**Key words:** dielectric fluids; electrical properties of fluids; high voltage measurements; Kerr coefficient; Kerr effect; nitrobenzene; pulse measurements; water.

The Kerr coefficients of both water and nitrobenzene were measured and the variation of these quantities with temperature and wavelength was investigated. At a temperature of 296 K and at a wavelength of 632.8 nm, the following values for the Kerr coefficients were obtained  $B(\text{C}_6\text{H}_5\text{NO}_2) = 3.24 \times 10^{-12} \text{ m/V}^2$ , and  $B(\text{H}_2\text{O}) = 3.43 \times 10^{-14} \text{ m/V}^2$ .

The estimated uncertainty in the measurement in nitrobenzene is  $\pm 6$  percent while in water the estimated uncertainty is  $\pm 8$  percent.

The primary conclusion drawn is that although nitrobenzene can be used for accurate measurement of a wide, and fairly well defined, variety of high voltage pulses, the situation in water is more poorly understood. The primary areas of difficulty using water are the existence of turbulence under pulses of duration of a few microseconds and the possibility of a voltage dependence of the Kerr coefficient due to a saturation of the alignment of the molecules with the applied field.

**NBSIR 74-545. Notes on the fundamentals of measurement and measurement as a production process**, P. E. Pontius, 65 pages (Sept. 1974). Order from NTIS as COM 74-11656.

**Key words:** calibration; comparator; interferometer; length; long gage blocks; measurement process; uncertainty.

The concept of a measurement process as a production process is relatively new, having evolved in the last ten years. There have been significant contributions from many sources which have served to refine the initial ideas. The generalized concept of a measurement process is discussed together with techniques and examples for verifying the validity of the result. While some of the techniques may not be appropriate for certain highly specialized measurement processes, it is felt that the concepts are applicable to practically all measurement processes. For certain types of general measurement processes, which must operate in a variety of environments, and which must accommodate a variety of materials and properties, the techniques have



been invaluable in understanding the manner in which measurement processes operate in a "real" world.

**NBSIR 74-550. Report to AID on an NBS/AID workshop on standardization and measurement services in industrializing economies, M. B. McNeil, 92 pages (May 11-24, 1974). Order from NTIS as COM 74-11755.**

Key words: AID; assistance; economics; foreign relations; industrializing nations; LDC's; measurement services; standardization.

On May 11-24, 1974, a Workshop was held at the National Bureau of Standards (Gaithersburg), under the sponsorship of AID, whose object was to give standards officials of industrializing nations insight into the standards and measurement systems in the United States and the role of the National Bureau of Standards, so that these officials might consider what parts of the U.S. system might usefully be adapted to conditions in their home countries. The report contains copies of speeches and presentations by representatives of both the U.S. and the industrializing nations, in addition to a general agenda of talks, presentations, and tours of laboratories both of NBS and of other organizations.

**NBSIR 74-551. An appraisal of methods for estimating self-reaction hazards, W. Tsang and E. S. Domalski, 100 pages (June 1974). Order from NTIS as COM 74-11658.**

Key words: activation energy; bond dissociation energy; computer programs; explosive sensitivity tests; heat of decomposition; oxygen balance.

The ability to identify and specify the thermal instability of chemical substances has been appraised as a result of examining certain test methods used to measure explosive sensitivity, and certain computer programs designed to estimate reaction hazards from a thermochemical approach. The bond dissociation energy emerges as the parameter giving the best correlation with material sensitivity. The computer programs overemphasize explosive power as opposed to explosive sensitivity and label many compounds hazardous when they are not. At present, regulations specifying the handling and transport of commodities should follow the concept of self-reactivity based upon functional groups.

**NBSIR 74-552. Technical manual for phosphor standards calibrator, M. L. Greenough and H. K. Hammond III, 84 pages (Aug. 12, 1974). Order from NTIS as COM 74-11644.**

Key words: fluorescence measurement; instrumentation, luminescence measuring; luminescence measurement; phosphorescence measurement.

This project involved two activities, 1) the fabrication and calibration of phosphor standards for use in the Postal Service Model 4A8 Phosphoremeter and 2) the construction of an instrument to perform the calibration function. Both of these relate to standardization of the phosphorescent and fluorescent activity of the luminescent coating applied to postage stamps by the Bureau of Engraving and Printing. The purpose of the luminescent coatings is to facilitate detecting the orientation of envelopes in facer-canceler machines during mail processing.

Work on the project entailed the fabrication of approximately 60 phosphor standards, which are hand-sized aluminum blocks into which stamp-sized wafers of luminescent materials are mounted. Fabrication was carried out following the specific procedures supplied by the Postal Service, with however, authority to verify or alter the process as necessary. On the other major project effort, an instrument was designed and constructed following in general the basic design of an earlier breadboard device developed under a prior project. In the system, quantitative evaluations are ultimately referred to calibrations at NBS of

the relative irradiance of a lamp in the ultraviolet and visible regions of the spectrum.

This report, one of two covering the project, is in the form of technical manual for the calibration instrument, and includes theory of operation, mechanical construction and detailed operating procedures.

**NBSIR 74-554. City games, disk and tape generation, J. Moriarty, 12 pages (Sept. 1973). Order from NTIS as COM 74-10703-2.**

Key words: city model; computer; computer disks; computer tapes; duplicate tapes and disks.

This document contains the instructions for initializing duplicate disks for the CITY I model and duplicate tapes for the CITY IV model.

**NBSIR 74-555. City games, an executive's overview, J. E. Moriarty, 50 pages (May 1974). Order from NTIS as COM 74-10704.**

Key words: city; computer; computer games; economic; government; metropolitan; simulation; social.

The City Games are realistic gaming simulations of the operation of contemporary cities. They have been in continuous development since the 1960s with their completion by the National Bureau of Standards in 1973-74. In the City Games, participants experience intensive transactions in collaborative planning and in competitive negotiations for the allocation of limited resources. They emulate elements of the government, economic and social sectors of the city system and make planning decisions involving land use, schools, transportation systems, water and sewer facilities, zoning, tax structure, etc., etc.. In a 3-hour round of game play, representing a telescoped fiscal year, the decision maker makes quantitative decisions, implements them, and (through the computer aided simulation) sees the consequences of his actions. In successive rounds of play, the participant gains experience in trade-off negotiations, learns systematic approaches to typical problems and acquires new insights into the interdependences of the numerous components of a city system. City Game demonstrations can be conducted over a 2-3 day period and can accommodate between 30 and 60 active participants.

**NBSIR 74-556. City games, mathematical foundations, J. E. Moriarty, Ed., 92 pages (Nov. 1973). Order from NTIS as COM 74-10703-1.**

Key words: computer programs; computers; computer simulation; equations; mathematical foundations; mathematics; simulation; simulation module.

The CITY models are operational simulation games in which the participants make economic, government and social decisions affecting a hypothetical metropolitan area. Through the use of a computer, the simulated urban system responds to the participant's decisions as any real city would. To simplify the description of the theory of the CITY GAMES modules, this manual is written for the four module game. The equations for the other games can easily be obtained by eliminating the descriptors that do not apply to the particular game of interest. The theoretical structure of all models is consistent and relevant only within the range from a central city area to a regional configuration. The description of the module components and equations are meant to show the scope of decisions including those by the user and by the programs and algorithms of the computer model.

**NBSIR 74-561. Analysis of methodology for measuring national highway traffic safety, R. G. Hendrickson and A. R. Craw, 42 pages (Sept. 1974). Order from NTIS as COM 74-11576.**



**Key words:** highway traffic safety; indicators; safety program impact; traffic data systems.

This report covers a critique of current measures used by NHTSA to report and evaluate National Traffic Safety, and presents the development of proposed measures for evaluating the impact of NHTSA priority programs on the vehicle-driver-highway mix. The proposed measures emphasize the use of injury-severity levels and an extended set of driver-vehicle-highway descriptors to depict critical factors in National traffic patterns and trends. The conclusions and recommendations address extensions of current indicators to describe accident phenomena by driver and vehicle attributes, to enlarge the number and detail of descriptors of accident data and accommodate these extensions by more comprehensive development. Surrogates for National statistics and concentration of certain programs were investigated.

**NBSIR 74-564. Development and analysis of techniques for calibration of Kerr cell pulse-voltage measuring systems VIII, R. E. Hebner, Jr., E. C. Cassidy, and R. J. Sojka, 55 pages (Aug. 21, 1974). Order from NTIS as COM 74-11726.**

**Key words:** calibration; electrical measurements; high voltage measurements; insulating fluids; Kerr coefficient; nitrobenzene; pulse voltage measurement; space charge; water.

This report documents recent progress in the refinement of techniques for accurate calibration of pulsed voltage measurement based on the electro-optic Kerr effect. The work includes a discussion of calibration techniques and a comparison of calibrations performed in various laboratories. In addition the Kerr coefficients of water, nitrobenzene and Halowax oil were determined. The measurements in Halowax oil were performed under direct, 60 Hz alternating, and pulsed high voltage. The measurements of the Kerr coefficient of nitrobenzene and water were performed under pulsed high voltage, but measurements of the space charge dynamics in nitrobenzene under low frequency alternating voltage are discussed.

**NBSIR 74-567. FY 74 progress report on design criteria and methodology for construction of low-rise buildings to resist typhoons and hurricanes, N. J. Raufaste, Jr., and R. D. Marshall, 276 pages (July 1, 1974). Order from NTIS as COM 74-11631.**

**Key words:** buildings; construction; data acquisition equipment; design criteria; extreme winds; information transfer; instrumentation; wind loads; wind tunnel modeling.

This report gives the major accomplishments of the second phase of a three year project to provide engineering and technical assistance to the Agency for International Development (AID), Department of State in developing improved design criteria for low-rise buildings to better resist extreme winds. During FY 74, the Center for Building Technology project staff members commenced several tasks. These tasks will serve as major inputs to the development of improved design criteria. The principal tasks include: 1) selecting a second and third field test site in the Philippines, 2) instrumenting four full scale houses, at the sites, 3) instrumenting the University of Philippines wind tunnel facility, 4) participating in an International Workshop at Manila during November 1973, and 5) developing, in conjunction with short-term consultants in Bangladesh and Jamaica, a methodology for the transfer of technology.

**NBSIR 74-568. FY 75 project plans Law Enforcement Standards Laboratory, 62 pages (Sept. 1974). Order from NTIS as COM 74-11578.**

**Key words:** communications equipment; forensic science; Law Enforcement Standards Laboratory; LESL; per-

formance standards; project plans; protective equipment; security equipment; standards.

Plans are presented for seventeen projects approved and funded for FY-75. They include plans for the preparation of performance standards, user guidelines and reports on law enforcement equipment in the communications, security, protective equipment, investigative aids, courtroom equipment and compliance testing areas.

**NBSIR 74-572. Torsional buckling of composite cylindrical shells, D. E. Marlowe and G. F. Sushinsky, 60 pages (Sept. 1974). Order from NTIS as COM 74-11791.**

**Key words:** aircraft structures; buckling; composite materials; metal reinforcement; stability; stacking sequence; thin shells; torsion.

The elastic buckling strength has been determined for thin-walled composite and composite-reinforced-metal cylindrical shells. Tests were performed on boron/epoxy and graphite/epoxy-all-composite specimens, on boron/epoxy-reinforced-titanium specimens and on boron/epoxy and graphite/epoxy-reinforced aluminum specimens. Cylinders were tested with several unidirectional-ply and cross-ply layups.

The results of the tests were compared with the buckling strengths predicted by the torsional buckling analysis of Chao. For the cylinders which fail by buckling, the experimental buckling torques were approximately 81 percent of the torques predicted by the analysis.

The experimental results of tests on 39 specimens are presented. Torsional buckling strengths which differ by as much as a factor of two may result from reversing the direction of twist of a thin-walled cross-ply composite cylinder. This has been shown to be equivalent to reversing the stacking sequence of the laminate. This is of potential importance in applications where reversals of loading may occur. An "optimum" stacking sequence which produced significant increases in the predicted and measured buckling loads was determined. Cylinders fabricated with this stacking sequence exhibit considerable increases in the strength-to-weight ratio over other sequences examined.

**NBSIR 74-577-1. Remittance processing system, Volume I (Refer to Volume II), P. D. Shupe, Jr., P. Meissner, and J. R. Park, 194 pages (Sept. 1974). Order from NTIS as COM 74-11723.**

**Key words:** audit trail; check endorsement; check handling; data entry; document labeling; labeling; listing; man machine interface; MICR printing; remittance processing; remittance register.

The Remittance Processing System is a prototype developed for the Internal Revenue Service to test a new concept in automating the processing of taxpayer remittances. Central to the new processing concept was the integration of the Direct Data Entry System. Initial Entry Station with equipment components that would eliminate a number of individual manual operations, permit operator interface with the central DDES computer, and provide for verification of initial entry, check endorsement, audit trail data, remittance documentation, and affixing information to taxpayer documentation accompanying the remittance. This report describes the equipment which was configured to implement these processes and to demonstrate the viability of the concept.

**NBSIR 74-577-2. Remittance processing system. Volume II (Reference Volume I), P. D. Shupe, Jr., P. Meissner, and J. R. Park, 317 pages (Sept. 1974). Order from NTIS as COM 74-11724.**

**Key words:** audit trail; check endorsement; check handling; data entry; document labeling; labeling; listing; man



machine interface; MICR printing; remittance processing; remittance register.

The Remittance Processing System is a prototype developed for the Internal Revenue Service to test a new concept in automating the processing of taxpayer remittances. Central to the new processing concept was the integration of the Direct Data Entry System. Initial Entry Station with equipment components that would eliminate a number of individual manual operations, permit operator interface with the central DDES computer, and provide for verification of initial entry, check endorsement, audit trail data, remittance documentation, and affixing information to taxpayer documentation accompanying the remittance. This report describes the equipment which was configured to implement these processes and to demonstrate the viability of the concept.

**NBSIR 74-578. Development of microwave hygrometer model III**, D. P. Stokesberry and S. Hasegawa, 14 pages (Sept. 1974). Order from NTIS as COM 74-11765.

Key words: dew-point; hygrometer; microwave hygrometer.

This is a progress report on the design and construction of NBS microwave hygrometer, Model III. The hygrometer is intended for field or laboratory operation with a dew point range of - 40 to 40° C.

**NBSIR 74-582. FY 1973 progress report on design criteria and methodology for construction of low-rise buildings to better resist typhoons and hurricanes**, N. J. Raufaste and R. D. Marshall, 31 pages (July 2, 1973). Order from NTIS as COM 74-11645.

Key words: construction; design criteria; extreme winds; full-scale test buildings; housing; instrumentation; wind tunnel.

This report highlights the major accomplishments of the initial phase of a three fiscal year project to provide engineering technical assistance to the Agency for International Development (AID) for the development of design criteria for low-cost/low-rise buildings to better withstand the effects of extreme winds. This phase represents approximately a 3 month level of effort. During this period CBT project staff members commenced six introductory tasks. These tasks will set the pace for the second

fiscal year level of effort. The tasks included: initiate dialogue with local organizations and institutes in developing countries, establish a local Philippine advisory committee; conduct on-site visits to developing countries to identify local professional candidates for short term consulting; conduct on-site visits to developed countries to collect information from research centers; purchase initial wind tunnel and full-scale field test instrumentation; and commence library search of related subject documents.

**NBSIR 74-595. A procedure for estimating automobile fuel consumption on congested urban roads**, D. M. Levinsohn and J. T. McQueen, 20 pages (Aug. 1974). Order from NTIS as COM 75-10057.

Key words: automobile fuel consumption; congestion; energy conservation; fuel consumption; impact assessment; roadway operating environment; urban roads; vehicle characteristics.

Energy consumption is an important measure of the performance of a transportation system. To be able to accurately measure associated automobile fuel consumption will improve the evaluation of urban transportation alternatives. An estimated procedure is proposed that is designed to be particularly sensitive to automobile fuel consumption in congested, peak hour traffic. This procedure is based upon vehicle attributes and roadway operating conditions which were determined through an extensive review of the auto fuel consumption literature. Vehicle attributes include characteristics of the automobile that affect fuel consumption. Roadway operating conditions comprise the types of driving to which the automobiles are subjected. Vehicles are classified by weight and model year. The proposed roadway classifications are expressway, arterial, and local street. For each vehicle type category, base fuel consumption rates are determined. These base consumption rates are then modified by adjustment factors which reflect the roadway operating conditions. The rates are multiplied by the vehicle miles of each vehicle category and summed over all categories to compute the total fuel consumption on the road under analysis. An example application of the procedure including sensitivity analyses is presented. The base fuel consumption rates can be obtained from EPA emissions test data. Research is required to determine the adjustment factors, particularly under conditions of extreme roadway congestion.

## 4. TITLES AND ABSTRACTS OF PAPERS PUBLISHED IN NON-NBS MEDIA, 1974

Reprints from the journals listed in this section may often be obtained from the authors. See page 5 for additional information.

- 13804.** Romanoff, M., Gerhold, W. F., Schwerdtfeger, W. J., Iverson, W. P., Sanderson, B. T., Escalante, E., Watkins, L. L., Alumbaugh, R. L., **Protection of steel piles in a natural seawater environment—Part I**, (Proc. 3d Int. Congress on Marine Corrosion and Fouling, Gaithersburg, Md., Oct. 2-6, 1972), Paper in *Proceedings: Third International Congress on Marine Corrosion and Fouling*, pp. 103-119 (Northwestern University Press, Evanston, Ill., Oct. 1973).

Key words: cathodic protection; coating index; corrosion rates; marine environment; polarization techniques; protective coatings; steel piling.

In a joint research effort between the National Bureau of Standards, the U.S. Army Corps of Engineers, and the U.S. Naval Civil Engineering Laboratory, the corrosion behavior of protected carbon and low alloy steel piling in seawater is being investigated. Nine-three "H" and pipe pile specimens, 35 feet long, were jettied into the Atlantic Ocean floor off the coast of Dam Neck, Va. The results of this study, which will take about 15 years to complete, will demonstrate which of the systems tested are best for protecting steel piles in seawater. Many types of protective methods are included in the investigation consisting of coating systems (coal-tar epoxy, hot-dip zinc, flamesprayed aluminum and zinc, zinc-rich paints, epoxies, etc.), cathodic protection by zinc and aluminum sacrificial anodes, and combinations of coatings and cathodic protection. At one-year intervals, polarization measurements and visual observations are made on the piles to determine the effectiveness of the coating systems and to measure the rates of corrosion. Potentials of cathodically protected piles are also measured. These data will be correlated with physical determinations made on the piles when they are removed from exposure. The first removal of one set of piles (31 in number) is scheduled for October 1972, after exposure for approximately 5 years.

- 13805.** Bennett, L. H., Swartzendruber, L. J., McNeil, M. B., **On the electron-configuration theory of marine corrosion**, (Proc. 3d Int. Congress on Marine Corrosion and Fouling, Gaithersburg, Md., Oct. 2-6, 1972), Paper in *Proceedings: Third International Congress on Marine Corrosion and Fouling*, pp. 410-426 (Northwestern University Press, Evanston, Ill., Oct. 1973).

Key words: alloy theory; catalysis; chemisorption; Cu-Ni alloys; d-bands; electron-configuration; metallurgy; passivity; rigid-band model; saltwater corrosion; surfaces.

The electron-configuration theory of corrosion introduced by Uhlig relates chemisorption and passivity to alloy compositions having favorable d-electron configurations. This theory postulates a critical composition for passivity which coincides with a theoretical filling of the d-band in a "rigid-band" description of these alloys. Recently, detailed knowledge of the electronic structure of Cu-Ni alloys has been greatly increased, and it no longer appears that a strict band model alone can give an adequate description of the disordered alloys. Recent theories and modern spectroscopic methods, including soft x-ray and photoelectron spectroscopy and other techniques, have provided a great deal of new knowledge concerning the electronic structure of Cu-Ni alloys. In light of these experimental and theoretical developments, this paper investigates whether or not there is

any evidence to support an electron-configuration theory of corrosion, without regard to the question of passivity, for Cu-Ni alloys in saltwater. The addition of small amounts of Fe has important effects on the corrosion rate in the copper-rich alloys and the relevance of this to the electron-configuration theory is considered. Effects of metallurgical variables and of film properties are noted. The related topic of heterogeneous catalysis is discussed.

- 13806.** Iverson, W. P., **The corrosion of mild steel by a marine strain of *Desulfovibrio***, (Proc. 3d Int. Congress on Marine Corrosion and Fouling, Gaithersburg, Md., Oct. 2-6, 1972), Paper in *Proceedings: Third International Congress on Marine Corrosion and Fouling*, pp. 61-82 (Northwestern University Press, Evanston, Ill., Oct. 1973). 340

Key words: anaerobic corrosion; depolarizing agent; ferrous ions; marine corrosion; *marine Desulfovibrio*; polarization techniques.

A marine strain of *Desulfovibrio* was isolated from steel piling detritus at Dam Neck, Va. A medium which provided good surface growth on 2 percent agar plates in a hydrogen atmosphere was developed (Trypticase, 15 gm; Phytone, 5 gm; NaCl, 5 gm; seawater, 1000 ml). The corrosion rate of mild steel in this medium, with and without the addition of  $\text{Fe}^{++}$  ions, was investigated using polarization techniques. In the absence of added  $\text{Fe}^{++}$  ions, the corrosion rate was found to decrease and then either increase or remain at a low level. In one corrosion cell a high rate of corrosion was accompanied by the formation of a corrosion product or products in the shape of "stalactite" formations. Analysis indicated free sulfur and an iron sulfur compound with iron in the  $\text{Fe}^{+++}$  state.

In the presence of added  $\text{Fe}^{++}$  ions, the corrosion rate was found to increase to 255 mdd in one corrosion cell and then decrease. Chemically prepared FeS produced little change in the potential or the corrosion rate. Corrosion of mild steel in a bacteria-free culture filtrate, to which  $\text{Fe}^{++}$  ions were added in excess to remove the  $\text{S}^{=}$  ions was extremely high. After an induction period of 3 days, the corrosion rate increased to a maximum of 1130 mdd 8 days after the start of the corrosion process. During the period of extensive corrosion, the potential of the steel dropped to more noble values.

When the black precipitate, formed upon the addition of  $\text{Fe}^{++}$  ions, was removed, the resulting filtrate was still highly corrosive, indicating that the depolarizing agent was water soluble and not the precipitate. The depolarizing agent appears to act as an electron carrier, removing electrons from the iron and transferring them to an acceptor which is thereby reduced. The action of this depolarizing agent could account for the high anaerobic corrosion rates observed in the field.

Inhibition of corrosion in cultures of *Desulfovibrio* appears to be due to the action of  $\text{H}_2\text{S}$  which reacts with the iron to form a protective film and prevents the actions of the soluble depolarizer.

- 13807.** Leasure, W. A., Jr., **Automobile tire noise: A review of the open literature**, (Proc. 1973 National Noise Control Engineering Conf., Washington, D.C., Oct. 15-17, 1973), Paper in *Noise-Con 73 Proceedings*, D. R. Tree, Ed., pp. 187-195 (Institute of Noise Control Engineering, Noise/News, Poughkeepsie, N.Y., Oct. 1973).



Key words: acoustics; automobile; noise (sound); tire noise; transportation noise.

Automobiles, the primary mode of transportation in the United States, contribute significantly to the noise environment due to the large number in operation. In this paper, one aspect of automobile noise is discussed, namely the contribution to overall vehicle noise made by the interaction of the tires with the road surface. For passenger cars, tire noise can be a significant contributor to overall levels at speeds as low as 35-40 mph and typically is the major contributor at higher speeds. Based on the limited data base available in the open literature, a discussion is given of the effects of various vehicle operational modes, tire mechanical properties, and road surface texture on the noise generated by passenger car tires. Both community noise and the noise heard by the occupants of the vehicle are considered. Possible noise generation mechanisms, although not well understood, are presented. Areas for future research and development are identified based on gaps in present knowledge.

**13808.** Corley, D. M., **Test of a proposed method for vehicle noise measurement**, (Proc. 1973 National Noise Control Engineering Conf., Washington, D. C., Oct. 15-17, 1973), Paper in *Noise-Con 73 Proceedings*, D. R. Tree, Ed., pp. 230-235 (Institute of Noise Control Engineering, Noise/News, Poughkeepsie, N.Y., Oct. 1973).

Key words: directivity; noise source level; sound pressure level; truck tire.

If a spherical pulsating source radiates into a infinite medium, the sound pressure is inversely proportional to the distance from the source. No real source exactly fulfills these conditions but it is generally assumed that far enough away from the source, spherical spreading will result. It has been proposed [Hixon, Inter-Noise 72, Washington, D.C.] that a measurement independent of distance results if both sound pressure level and distance from the source are monitored and the sound pressure level is normalized to a constant distance, e.g., 1 meter, from the source. This measurement is deemed Noise Source Level. Data exist for tires which can indicate the merit of this approach [W. Leasure et al, DOT-OST-ONA 71-9]. These data consist of sound pressure level and distance from the source simultaneously monitored as unpowered trucks coast past an array of microphones. The A-weighted Noise Source Level from three types of truck tires with tread designs representative of tread patterns in common use today are presented. It is concluded that spherical spreading is generally not the case even 500 feet from the source. The r-dependence is not satisfactorily removed by this method of analysis. Therefore considerable care should be exercised if Noise Source Level is used to characterize truck tire noise levels. Noise Source Level does appear to be useful for presenting source directivity.

**13809.** Bender, P. L., Currie, D. G., Dicke, R. H., Eckhardt, D. H., Faller, J. E., Kaula, W. M., Mulholland, J. D., Plotkin, H. H., Poultney, S. K., Silverberg, E. C., Wilkinson, D. T., Williams, J. G., Alley, C. O., **The lunar laser ranging experiment**, *Science* **182**, 229-238 (Oct. 1973).

Key words: celestial mechanics; crustal movements; earth rotation; geophysics; laser; moon; polar motion; selenodyssey.

The data obtained so far by the McDonald Observatory have been used to generate a new lunar ephemeris based on direct numerical integration of the equations of motion for the moon and planets. With this ephemeris, the range to the three Apollo retroreflectors can be fit to an accuracy of 5 meters by adjusting the differences in momenta of inertia of the moon about its principal axes, the selenocentric coordinates of the reflectors, and the McDonald longitude. The accuracy of fitting the results is limited currently by errors of a few arc sec in the angular orienta-

tion of the moon, as derived from the best available theory of how the moon rotates in response to the torques acting on it. A new calculation of the moon's orientation as a function of time based on direct numerical integration of the torque equations is expected to considerably improve the accuracy of fitting the data.

**13810.** Unassigned.

**13811.** Thomas, R. N., Gebbie, K. B., **Theory of stellar atmospheres**, *Trans. Int. Astron. Union* **15A**, 537-569 (1973).

Key words: stellar atmospheres.

This report has been prepared by the President in collaboration with the Secretary of the Commission. It is based on (1) material supplied by those members and associates of the Commission who responded to requests made in our circulars, (2) a bibliographical search intended to supplement the above material, (3) discussions with other interested persons, and (4) our own knowledge and impressions of the activity within the province of the Commission over the last three years. The report is divided into three parts. Part A is a scientific review aimed not at a comprehensive summary of all work but at a selective review of that which has, in our opinion, introduced some significant change in our concept of a stellar atmosphere or in the likely direction of future developments. Part B is a bibliography. It is this part of the report that is intended to provide an exhaustive summary of work done in the field over the last three years. To authors of those papers we have inadvertently omitted, we offer our apologies: neither were they sent to us nor did we locate them ourselves. Finally, Part C is an outline of the aims and activities of the Commission.

The decision to write the entire report ourselves, rather than delegate specific sections to other people, was aimed at providing a more coherent approach to the subject as a whole. Clearly, this represents only one of many possible approaches, and the form of the report is highly individual. The choice of what to include without encroaching on the fields of other commissions has become increasingly difficult. No longer can Commission 36 confine itself to theoretical models of stellar atmospheres. Empirical analyses that reveal inconsistencies in our theoretical assumptions must also be included, as must some consideration of solar phenomena, which are now recognized as being relevant to a wide variety of stars. Reference must also be made to those results of physics that are immediately applicable to the theory of stellar atmospheres. Inevitably, the selection has to some extent been arbitrary.

**13812.** Flynn, D. R., Leasure, W. A., Jr., **Machinery noise: Measurement standards and test codes**, (Proc. 1973 National Noise Control Engineering Conf., Washington, D.C., Oct. 15-17, 1973), Paper in *Noise-Con 73 Proceedings*, D. R. Tree, Ed., pp. 257-260 (Institute of Noise Control Engineering, Noise/News, Poughkeepsie, N.Y., Oct. 1973).

Key words: acoustics; noise; soundpower.

Measurements of the sound power emitted by machinery, or of the sound pressure at specific locations, are needed for a variety of purposes. These include measurements for diagnostic and control purposes, measurements for labeling (explicitly or implicitly) the noise emission from a product, and measurements to determine compliance with specifications or regulations. A brief discussion is given of the general items which should be included in noise measurement standards and test codes. An example of standards addressing these points is the series of basic documents on sound power level measurements being prepared under the auspices of the International Organization for Standardization.

**13813.** Cameron, J. M., Plumb, H., **Traceability — with special**



reference to temperature measurement, *Soc. Automot. Eng. Trans.* 78, Section 3, 1586-1590 (1969).

Key words: calibration; temperature; traceability.

The requirement that measurements be traceable to national standards arose in response to needs for consistency between different parts of the measurement system. There is one single agreed-upon definition for traceability, but it has been taken to mean the existence of some chain of intercomparisons or calibrations leading back to the National Bureau of Standards. Like all procedural or material requirements, its presence or absence may bear little relation to the performance characteristic one is really interested in. The scientific problem of expressing the desired performance requirements in terms of the amount and type of evidence needed to determine the degree of consistency of measurement processes is discussed and illustrated for the measurement of temperature. The importance of the study of measurement as a production process and the need for a program for the surveillance of the measurement process is discussed and plans for a new service for transfer of measurement capability in thermometry are presented.

13814. Cook, R. K., **The use of modulated reverberation for measurement of absorption and sound power**, (Proc. 1973 National Noise Control Engineering Conf., Washington, D.C., Oct. 15-17, 1973), Paper in *Noise-Con 73 Proceedings*, D. R. Tree, Ed., pp. 303-308 (Institute of Noise Control Engineering, Noise/News, Poughkeepsie, N.Y., Oct. 1973).

Key words: acoustical measurement; noise control; sound power.

A source of sound power modulated in amplitude 100 percent at a very low sinusoidal frequency  $F$  is introduced into a reverberation chamber. The total acoustical energy in the sound field will have an amplitude modulation at the same frequency  $F$ , but lagging in phase by  $\phi$  due to the absorption in the chamber. An analysis of the differential equation for energy and sound power balance yields (1) the absolute cross-section  $A$  for absorption, and (2) the time-averaged absolute sound power  $W_0$  of the source. Measurements  $A$  and  $W_0$  have been made at various audio frequencies in the 425 m<sup>3</sup> reverberation chamber of the Bureau. The modulated source of sound power was electroacoustical—an array of four loudspeakers having their audio input voltage waveforms amplitude-modulated at  $F=0.1$  to 0.4 Hz. The sound pressure  $|p^2|$  was measured with an array of four microphones. The phase  $\phi$  was obtained by means of an analog computer based on a least squares principle of design. For a steady source of sound power, e.g., a noisy machine, a modulated sound field can be produced by modulating (as a function of time) the absorption cross-section of the reverberation chamber. We present the analysis for energy and sound power balance, and examine some methods for achieving modulated absorption cross-sections.

13815. O'Connell, J. S., **Electromagnetic interactions of the few-nucleon systems**, *Proc. Seminar Electromagnetic Interactions of Nuclei at Low and Medium Energies, Moscow, U.S.S.R., Dec. 11-13, 1972*, pp. 299-309 (Dec. 1973).

Key words: deuterium; electron scattering; helium-3; helium-4; photonuclear; weak interactions.

Recent progress on the photodisintegration electron scattering reactions on the hydrogen and helium isotopes is reviewed. The connection to weak interactions and the effect of meson dynamics on few-nucleon properties and reactions are discussed.

13816. Post, M. A., **Liquid latex paint analysis**, *Paint Varnish Prod. Part 1*, 63, No. 9, 21-25 (Sept. 1973); *Paint Varnish Prod. Part 2*, 63, No. 10, 27-38 (Oct. 1973).

Key words: acrylic; alkyd modified latex paints; deep-tone

latex paints; infrared spectroscopy; polyvinyl acetate; styrene-acrylate; vinyl-acrylic; vinyl acetate-dibutyl maleate; vinyl acetate-ethylene; vinyl acetate-ethyl acrylate; vinyl acetate-2-ethyl-hexyl acrylate; vinyl chloride-acrylate.

The qualitative identification by infrared spectroscopy of latex resins, the quantitative determination of the latex resin and alkyd modifier in alkyd modified latex paints and of the latex resin in unmodified latex paints are discussed. Four procedures for latex resin identification and two methods for quantitative determination of the latex resin are presented. One of the quantitative methods can be used for any latex paint. The other, which is shorter is useful only for paints based on polyvinyl acetate, vinyl acetate-dibutyl maleate and vinyl-acrylic copolymers.

13817. Hummer, D. G., Seaton, M. J., **Interpretation of the spectra of planetary nebulae**. Introductory Report, *Mem. Soc. Roy. Sci. Liege V*, 225-238 (1973).

Key words: forbidden lines; nebular spectra; planetary nebulae; recombination spectra.

Progress since 1967 in the interpretation of nebular spectra is reviewed.

13818. Keller, R. A., **Tunable lasers for chemists**, *Chem. Technol.*, 626-634 (Oct. 1973).

Key words: dye laser; isotope separation; photochemistry; review; saturation spectroscopy; spectroscopic analysis.

A general review of organic dye lasers and their use in the fields of: analytical chemistry, chemical synthesis and separation, photobiology, and spectroscopy is presented. The text includes 47 references.

13819. Mordfin, L., Robusto, R., Jr., **Plastic deformation characteristics of refractory metals above 3000 °F**, (Proc. 5th National Society for the Advancement of Material and Process Engineering Technical Conf., Kiamesha Lake, N.Y., Oct. 9-11, 1973), Paper in *Materials & Processes for the 70's* 5, 378-393 (SAMPE, National Business Office, Azusa, Calif., Oct. 1973).

Key words: evaluation; high temperature tests; molybdenum; plastic flow; Poisson ratio; refractory metals; strain hardening; strain rate; stress strain diagrams; tantalum; tensile properties.

Using a photographic strain-measuring technique, exploratory tensile tests were conducted to investigate the plastic behavior of unalloyed molybdenum and tantalum in the hot-working temperature range. Several unusual characteristics were observed, including serrated flow, a negative strain-rate sensitivity and, in one case, considerable strain hardening. These observations indicate a need for further research in this area, before hot-working processes for refractory metals can be made practical.

13820. Hayward, E., Barber, W. C., Sazama, J., **Nuclear scattering of plane-polarized photons**, *Phys. Rev. C* 8, No. 3, 1065-1073 (Sept. 1973).

Key words: dynamic collective model; giant resonance; nuclear surface oscillations; photon scattering; polarized photons; tensor polarizability.

A beam of plane-polarized monochromatic photons has been produced by the resonance fluorescence of the well-known  $1^+$  state at 15.1 MeV in  $^{12}\text{C}$ . These have been scattered a second time from natural targets of Cd, Sn, Ta, W, Pt, Au, and Bi. Measurements were made with poor energy resolution of the relative number of photons scattered at 90° parallel and perpendicular to the polarization vector in the incident 15.1-MeV beam. The observation of photons scattered along the polarization vector reflects the contribution of incoherent scattering to the dominant coherent-scattering process and results either from permanent



nuclear deformation or from the dynamic deformation produced by the coupling of the giant dipole resonance with the quadrupole oscillations of the nuclear surface. The observed intensities of incoherent scattering are of the same order of magnitude for the deformed nuclei and the spherical vibrators and agree roughly with the predictions of the dynamic collective model. No incoherent scattering was observed from the rigid sphere  $^{209}\text{Bi}$ .

- 13821.** Tschiegg, C. E., Greenspan, M., **Helmholtz resonators as sonic bubble chambers?**, *J. Acoust. Soc. Amer.* **54**, No. 4, 1112-1113 (Oct. 1973).

Key words: bubble chamber; Helmholtz resonators; rapid-cycling bubble chamber; sonic bubble chamber.

It has been found possible to develop alternating pressures of up to 10 atm in liquid-filled Helmholtz resonators. Some advantages and disadvantages of the construction of a rapid-cycling bubble chamber along such lines are discussed.

- 13822-13831.** Unassigned.

- 13832.** Mies, F. H., **Stimulated emission and population inversion in diatomic bound-continuum transitions**, *Mol. Phys.* **26**, No. 5, 1233-1246 (1973).

Key words: continuum emission; lasers; line shapes; molecular spectroscopy; quantum chemistry; stimulated emission.

Exact expressions are derived for the rate of stimulated emission and the conditions for population inversion in a diatomic bound-continuum transition. The resultant formulae resemble those of a simple, homogeneously broadened, discrete transition with the Lorentzian lineshape replaced by a continuum lineshape,  $g^c(h\nu = E_{v'} - \epsilon'')$ , which is approximately equal to the square of the overlap between the initial, emitting, vibrational level  $v'$  and the final, energy-normalized continuum state  $\epsilon''$ , i.e.  $g^c \approx \langle v' | \epsilon'' \rangle^2$ . Using the "reflection method," which is most applicable to a strongly repulsive final state, equations are obtained which allow simple, but accurate, estimation of the pertinent parameters which influence lasing action. Some general conclusions are extracted, and specific results are presented for the stimulated vacuum ultraviolet emission in high pressure Xe.

- 13833.** Carrington, C. G., Drummond, D., Gallagher, A., Phelps, A. V., **Oscillations in continuum molecular spectra of alkali-metal-noble-gas molecules**, *Chem. Phys. Lett.* **22**, No. 3, 511-514 (Oct. 15, 1973).

Key words: alkali-metal; continuum; molecules; rare-gas; spectra.

Regular intensity undulations in the continuum spectra of heavy diatomic molecules are reported. In particular, the  $\text{AII-X}\Sigma$  transition of the Rb-noble-gas Cs-noble-gas molecules has been studied. Calculations as well as experimental observations of absorption and emission spectra are reported.

- 13834.** Taylor, P. O., Dunn, G. H., **Absolute cross sections and polarization for electron-impact excitation of the K and H resonance lines of the  $\text{Ca}^+$  ion**, *Phys. Rev. A* **8**, No. 5, 2304-2321 (Nov. 1973).

Key words: Ca II; electron impact; excitation cross sections; polarization; resonance lines.

Crossed beams of electrons and  $\text{Ca}^+$  ions have been used to measure absolute cross sections for electron-impact excitation of the resonance K and H lines of Ca II at 3934 and 3968 Å, respectively. Polarization fractions of the light were also measured. The cross sections presented are absolute in the sense that all measurables including photon flux, have been compared to relevant standards. The cross section for excitation of the K line is observed to have a value of about  $(18 \pm 2)\pi a_0^2$  at the 3.15-eV threshold, and to decrease to a magnitude of  $(1.5 \pm 13)\pi a_0^2$  at

700-eV electron energy. Experimental uncertainties have been presented at the 98 percent confidence level, typically three standard deviations of random fluctuations combined in quadrature with the systematic uncertainties. The experimental results for both the K and H emissions are in agreement at 350 eV with the Coulomb distorted-wave calculation of Burgess and Sheorey but lie about 35 percent below the low-energy three-state close-coupling calculations of Burke and Moores. The ratio of the cross sections for the K and H emission is found to be 2.0 at all energies. Detailed study of the cross section at low energies demonstrates the expected finite value at threshold (within the accuracy allowed by the electron energy spread of 0.3 eV), and does not indicate the presence of a large (greater than 5%) contribution from cascade. Structure in the K cross section about 2 eV above threshold suggests interactions with autoionizing levels of Ca I, presumably belonging to the  $5snl$  or  $4dnl$  series. The polarization fraction at low energy is about 25 percent higher than the calculation of Saraph which is based on the Burke and Moores close-coupling calculation.

- 13835.** Liebman, J. F., **Regularities and relations among ionization potentials of nontransition elements**, *J. Chem. Educ.* **50**, No. 12, 831-834 (Dec. 1973).

Key words: atoms; extrapolation; ionization potentials; nontransition elements; semiempirical rules.

In this paper, we ask "How does the ionization potential vary with increasing atomic number?" and in addition inquire about higher ionization potentials. Five classes of semiempirical procedures are given, utilized and discussed. Two new procedures are introduced and found to be reliable.

- 13836.** Clough, S. A., Beers, Y., Klein, G. P., Rothman, L. S., **Dipole moment of water from Stark measurements of  $\text{H}_2\text{O}$ , HDO, and  $\text{D}_2\text{O}$** , *J. Chem. Phys.* **59**, No. 5, 2254-2259 (Sept. 1, 1973).

Key words: dipole moment; Stark effect; water.

The equilibrium dipole moment of the water molecule has been determined from Stark effect measurements on two  $\text{H}_2\text{O}$ , one  $\text{D}_2\text{O}$ , and six HDO rotational transitions. The variation of the dipole moment projection operator with rotational state is taken into account and expressions are given for this operator evaluated in the ground vibrational states of the three isotopes. The value obtained for the equilibrium dipole moment is  $|\mu_x| = 1.8473 \pm 0.0010$  D. The effective dipole moments in the principal axis energy representation are  $|\mu_b(\text{HOH})| = 1.8546 \pm 0.0006$  D,  $|\mu_b(\text{DOD})| = 1.8558 \pm 0.0021$  D and  $|\mu_b(\text{DOH})| = 1.7318 \pm 0.0009$  D,  $|\mu_a(\text{DOH})| = 0.6567 \pm 0.0004$  D.

- 13837.** Weisman, I. D., Swartzendruber, L. J., Bennett, L. H., **Nuclear resonances in metals: Nuclear magnetic resonance and Mössbauer effect**, Chapter 9 in *Techniques in Metals Research*, E. Passaglia and E. Bunshah, Eds., **6**, Part 2, 165-504 (John Wiley and Sons, Inc., New York, N.Y., 1973).

Key words: experimental techniques; ferromagnetic nuclear resonance; metallurgy; Mössbauer effect; nuclear magnetic resonance; pure quadrupole resonance.

It is the purpose of this chapter to review nuclear magnetic resonance, nuclear quadrupole resonance, ferromagnetic nuclear resonance and the Mössbauer effect in metals, alloys and intermetallic compounds. The emphasis is on the technique of measurement, and includes only such theory as is deemed essential to understand the purpose of the measurement, its limitations, the sample preparation required, and when a particular kind of measurement is most appropriate.

- 13838.** Soulen, R. J., Jr., Schooley, J. F., Evans, G. A., Jr., **Simple instrumentation for the inductive detection of supercon-**



ductivity, *Rev. Sci. Instrum.* **44**, No. 10, 1537-1538 (Oct. 1973).

Key words: ac susceptibility; superconductivity; temperature; thermometric fixed point.

A circuit is described which can be used to detect the superconductive transitions of several elements used as thermometric fixed points. The circuit is found to perform as well as much more elaborate mutual inductance bridges previously used for this research. Details for construction and operation for the circuit are given.

**13839.** Swanson, N., Cooper, J. W., Kuyatt, C. E., **Resonant structure in near-threshold electron excitation of krypton**, *Phys. Rev. A* **8**, No. 4, 1825-1834 (Oct. 1973).

Key words: electron excitation; high resolution; krypton; resonance.

By using a monochromator-analyzer combination, electron-excitation functions of the lowest-lying electronic states of krypton have been obtained at a scattering angle of  $45^\circ$  in the near-threshold region (9-14 eV). All excitation functions display a complex resonant structure. Additional data have been obtained on elastic scattering at  $45^\circ$  to provide further information on the resonances. In addition to the  $4p^55s^2 J=3/2, 1/2$  resonance doublet, a number of narrow resonances appear below about 12 eV in both the excitation data and elastic scattering which correlate in energy with recent measurements on transmission by Sanche and Schulz. Broad resonant structure is found in a number of the excitation curves and the excitation process in the near-threshold region appears to be dominated by resonant effects. An analysis of the elastic-scattering data on the  $4p^55s^2$  doublet is presented and resonance parameters obtained compared with theory. A comparison of the narrow resonant structure data with optical absorption data Rb I obtained by Beutler indicates that the narrow resonances in the 10.5 - 12-eV region are probably due to levels of the  $4p^55s4d$  configuration.

**13840.** Jacox, M. E., Milligan, D. E., **Matrix-isolation study of the reaction of H atoms with NO. The infrared spectrum of HNO**, *J. Mol. Spectrosc.* **48**, No. 3, 536-559 (Dec. 1973).

Key words: force constants; H + NO reaction; HNO; infrared spectrum; matrix isolation; thermodynamic properties.

Studies of the reaction with NO in an argon or a nitrogen matrix at  $4^\circ$  or 14 K of H and D atoms produced either photolytically or in a microwave discharge have confirmed the previous identification of the ground-state NO stretching fundamental of HNO and of DNO but have dictated a reassignment of the deformation fundamental of these two species. An absorption at  $1153\text{ cm}^{-1}$  has been assigned as the deformation fundamental of DNO, and evidence is presented suggesting that the deformation fundamental of HNO lies very close to  $1500\text{ cm}^{-1}$ . The assignment of an absorption at  $2717\text{ cm}^{-1}$  as the NH stretching fundamental of HNO and of an absorption at  $2043\text{ cm}^{-1}$  as the corresponding fundamental of DNO is consistent with the previous report of an exceptionally long NH bond for ground-state HNO. Detailed isotopic studies support this revised vibrational assignment, which is shown to be consistent with previous gas-phase studies. The force constants and thermodynamic properties of ground-state HNO derived from the matrix data are presented.

**13841.** Lovas, F. J., Johnson, D. R., **Reaction of  $\text{BF}_3$  with  $\text{NH}_3$ : Microwave spectrum of  $\text{BF}_2\text{NH}_2$** , *J. Chem. Phys.* **59**, No. 5, 2347-2353 (Sept. 1, 1973).

Key words: aminodifluoroborane; dipole moment; gas-phase reaction; microwave spectrum; molecular structure; rotational transitions.

Microwave spectra assignable to gas phase

aminodifluoroborane ( $\text{BF}_2\text{NH}_2$ ) have been detected in the reaction of  $\text{BF}_3$  with  $\text{NH}_3$ . A centrifugal distortion analysis has been carried out on the species  $^{11}\text{BF}_2^{14}\text{NH}_2$  and  $^{10}\text{BF}_2^{14}\text{NH}_2$ . Distortion corrected rotational constants have also been obtained for  $^{11}\text{BF}_2^{15}\text{NH}_2$ ,  $^{10}\text{BF}_2^{15}\text{NH}_2$ ,  $^{11}\text{BF}_2^{14}\text{ND}_2$ , and  $^{10}\text{BF}_2^{14}\text{ND}_2$ . The molecule has been found to be planar with the following geometry:  $r_{\text{B-F}} = 1.325(12)\text{ \AA}$ ,  $r_{\text{B-N}} = 1.402(24)\text{ \AA}$ ,  $r_{\text{N-H}} = 1.0029(18)\text{ \AA}$ ,  $\angle\text{FBF} = 117.9(17)^\circ$  and  $\angle\text{HNN} = 116.94(30)^\circ$ . The observed dipole moment of  $\text{BF}_2\text{NH}_2$  is  $\mu = 2.595(30)\text{ D}$ .

**13842.** Haynes, W. M., **Viscosity of gaseous and liquid argon**, *Physica* **67**, No. 3, 440-470 (Aug. 1973).

Key words: argon; compressed gas and liquid; dilute gas; saturated liquid; torsional crystal viscometer; viscosity.

The coefficient of shear viscosity of fluid argon has been measured at temperatures from 85 to 298 K and at pressures up to  $34\text{ MN/m}^2$  using the torsional crystal viscometer. The precision and accuracy of these measurements were estimated to be 0.5 and 2 percent, respectively. A detailed description of the apparatus and experimental measuring techniques is presented. Viscosity data for the compressed gas were represented and analyzed using density expansions. An empirical relation was developed to represent the data over the entire fluid range as a function of density and temperature. Also included is a comprehensive comparison of the present results with previous experimental data and theoretical predictions.

**13843.** Weisman, I. D., Bennett, L. H., Maxwell, L. R., Sr., **In vivo NMR relaxation studies of tumors**, *IEEE Trans. Magn. MAG-9*, No. 3, 454-456 (Sept. 1973).

Key words: in vivo; melanoma; nuclear magnetic resonance; spin-lattice relaxation; spin-spin relaxation; tumor.

Pulsed nuclear magnetic resonance has been used to differentiate between normal mouse tail tissue and a malignant transplanted melanoma S91 located on the tail of a live mouse. Measurements of proton spin-lattice and spin-spin relaxation serve to detect and monitor the tumor growth. The mature tumor exhibits a spin-lattice relaxation time  $T_1$  of  $\sim 0.7\text{--}0.8\text{ s}$  contrasting with the corresponding normal tail tissue  $T_1$  of half this value. On the other hand spin-spin relaxation in normal tissue cannot be characterized by a single relaxation time  $T_2$ . The corresponding relaxation in a mature tumor is found to be closer to a single exponential but still requires at least two superimposed exponential decays.

**13844.** deWit, R., **Continuous distribution of disclination loops**, *Phys. Status Solidi (a)* **18**, 669-681 (Aug. 1973).

Key words: burgers vector; continuous defect distribution; disclination; dislocation; distortion elasticity; Frank vector; loop; plasticity.

Kroupa's theory of a continuous distribution of dislocation loops is extended to include disclination loops. The relation of the loop densities to the plastic strain and bend-twist are derived. This provides the connection with the theory of the continuous distribution of dislocations and disclinations. Mura has recently introduced the new concepts of "plastic distortion" and "plastic rotation," and they are identified in this paper as the dislocation- and disclination-loop density tensors. The significance of these quantities for a finite loop is discussed.

**13845.** Johnson, C. R., **A Gersgorin inclusion set for the field of values of a finite matrix**, *Proc. Amer. Math. Soc.* **41**, No. 1, 57-60 (Nov. 1973).

Key words: eigenvalues; field of values; Geršgorin set; numerical radius; spectrum; subadditive set valued function.

An easily computed Geršgorin type inclusion set for the field







**Key words:** alumina; crack growth; critical stress intensity factor; fracture; plastic deformation; sapphire; strength; transmission electron microscopy.

At low temperatures, metastable crack growth dictates the environment free strength of sapphire. Plastic deformation by dislocation motion or twin formation and growth plays no role in the fracture process at temperatures below 400 °C. These conclusions are supported both by crack growth studies and critical stress intensity factor measurements on sapphire crystals, and by transmission electron microscopy studies of arrested cracks in sapphire and alumina.

- 13854.** Chandler, H. H., Bowen, R. L., Paffenbarger, G. C., Mullineaux, A. L., **Clinical evaluation of a radiopaque composite restorative material after three and a half years**, *J. Dent. Res.* **52**, No. 5, 1128-1137 (Sept.-Oct. 1973).

**Key words:** clinical evaluation; clinical research; composite restorations; dental restorations; dentistry; monomers; operative dentistry; reinforcements.

A clinical comparison was made of an experimental radiopaque composite restorative material and Addent 35. The radiopaque experimental formulation contained a novel ternary eutectic dimethacrylate as the resin binder and fused silica and a novel BaF<sub>2</sub>-containing glass as the reinforcing fillers. Evaluation of restorations indicate that the experimental material compared favorably with the commercial material.

- 13855.** Arni, H. T., **Precision of air-permeability, turbidimeter, and No. 325 sieve fineness data**, *Amer. Soc. Testing Mater. Spec. Tech. Publ.* **473**, pp. 20-44 (1970).

**Key words:** air-permeability; cements; fineness; No. 325 sieve; portland cements; precision; tests; Wagner turbidimeter.

Data on air-permeability and turbidimeter fineness from an interlaboratory test program involving eight different portland cements and from about 80 to 150 laboratories over a period of a year and a half are presented and analyzed from the standpoint of between-laboratory and within-laboratory precision. Scatter diagrams for the four pairs of samples are presented and used as an aid in the analysis. For six of the cements, results of determinations of fineness by the No. 325 sieve are also analyzed and scatter diagrams shown. The effect on the calculated standard deviation of the elimination of some outlying results is assessed. A method of determining within-laboratory or single-laboratory precision without the use of duplicate determinations is presented. Laboratory bias was found to be significantly larger than the random error for all three tests. There was no indication of any significant difference in precision or in laboratory bias between the Type I and Type IA cements for any of the tests.

- 13856.** Chow, L. C., Brown, W. E., **Phosphoric acid conditioning of teeth for pit and fissure sealants**, *J. Dent. Res.* **52**, No. 5, 1158 (Sept.-Oct. 1973).

**Key words:** enamel; hydroxyapatite; monocalcium phosphate monohydrate; pit and fissure sealant; phosphoric acid.

It is shown that monocalcium phosphate monohydrate, Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub> · H<sub>2</sub>O, forms on enamel surface during the H<sub>3</sub>PO<sub>4</sub> conditioning of teeth administered prior to application of pit and fissure sealants. The Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub> · H<sub>2</sub>O coating appears to protect teeth from excessive dissolution during the pretreatment and is washed away subsequently to provide a clean surface available for adhesion to sealant. These phenomena are in complete accord with the phase diagram for the ternary system Ca(OH)<sub>2</sub>OH<sub>3</sub>PO<sub>4</sub> - H<sub>2</sub>O.

- 13857.** Flatto, L., Haber, S., **A quadrature formula of degree three**, *J. Approximation Theory* **9**, No. 1, 44-52 (Sept. 1973).

**Key words:** Hilbert basis; integration; invariants; multiple integrals; numerical integration; quadrature; reflection groups; symmetric groups; symmetries.

Let  $R$  be a region in  $n$ -space and  $Q$  a linear quadrature formula for  $R$  of the form

$$Q(f) = \sum_{r=1}^k a_r f(x_r).$$

It is known that if  $Q(f) = \int_R f$  whenever  $f$  is a polynomial of degree 3 or lower, then  $k \geq n+1$ . It is known that the minimum possible value of  $k$  depends on the region  $R$ , being  $2n$  for the  $n$ -cube and  $n+2$  for the  $n$ -simplex ( $n > 1$ ). In 1956 Hammer and Stroud conjectured that  $k \geq n+2$  for every  $R$ , when  $n > 1$ . In this paper we construct an  $R$ , and a  $Q$  with the required property, with  $k = n+1$ .

- 13858.** Haber, S., Shisha, O., **An integral related to numerical integration**, *Bull. Amer. Math. Soc.* **79**, No. 5, 930-932 (Sept. 1973).

**Key words:** bounded variation; improper integral; monotonicity; numerical integration; quadrature; Riemann integral.

The question of the convergence of numerical integration formulas (of Riemann sum type) to the improper Riemann integral  $\int_0^\infty f(x)dx$  is studied. A new integral over  $[0, \infty)$ , more restrictive than the improper Riemann integral but not absolutely convergent, is introduced. Necessary and sufficient conditions are found for a function to be integrable in the new sense; they are stated in terms of property of functions similar to the property of being of bounded variation. A convergence theorem for the numerical integration of such functions is given.

- 13859.** McCulloh, K. E., **Photoionization of carbon dioxide**, *J. Chem. Phys.* **59**, No. 8, 4250-4259 (Oct. 15, 1973).

**Key words:** carbon dioxide; CO<sup>+</sup>; CO<sub>2</sub><sup>+</sup>; dissociative ionization; O<sup>+</sup>; photoionization.

The yields of photoions from CO<sub>2</sub> cooled to 150 K have been measured at a resolution of 0.22 Å for CO<sub>2</sub><sup>+</sup> and 0.4 Å for the O<sup>+</sup> and CO<sup>+</sup> fragments, in the photon energy region extending from onset for each species to approximately 20 eV. Most of the observed structure of the molecular ion yield curve recapitulates the well known features of the absorption spectrum, but a number of anomalies are reported. Autoionization peaks at photon energies just above the first molecular ionization limit of 13.773 ± 0.002 eV do not fit into a pattern characteristic of Rydberg series converging to excited vibrational levels of the ion. Although the Tanaka-Ogawa series and Henning's sharp series can be assigned as  $ns$  Rydberg series on the basis of quantum defects, the expected  $3s$  members could not be observed in the present study. The most prominent feature of the O<sup>+</sup> yield curve is a step at 19.39 eV, suggesting that the principal mechanism for production of this fragment is predissociation of CO<sub>2</sub><sup>+</sup>(C<sup>2</sup>Σ<sub>g</sub><sup>+</sup>) in its ground vibrational state. Completeness of this predissociation is inferred, although the proposed explanation involves doublet-quartet mixing at large bending angles. The structure of the O<sup>+</sup> yield curve between 19.07 and 19.39 eV suggests that Rydberg states converging to CO<sub>2</sub><sup>+</sup>(C) also undergo predissociation, with spontaneous ionization, to produce this fragment ion. Evidence pertaining to production of CO<sup>+</sup> fragments by predissociation of excited vibrational states of CO<sub>2</sub><sup>+</sup>(C) is also presented.

- 13860.** Cezairliyan, A., **Change in normal spectral emittance (at 650 nm) of niobium during melting and its relation to surface roughness**, *Surface Sci.* **40**, 429-432 (1973).

**Key words:** high temperature; melting; niobium; normal spectral emittance; surface roughness.

Investigations on the normal spectral emittance (at 650 nm) of



niobium during melting are reported. An attempt is made to relate the difference between the emittance of solid and liquid niobium at the melting point to the roughness of the solid surface. The results indicate that this difference is primarily due to conditions of the solid surface.

- 13861.** Keller, R. A., Simmons, J. D., Jennings, D. A., **Enhancement of absorption spectra by dye-laser quenching, III: Quantitative aspects and a comparison of flash-lamp-pumped and cw systems under high resolution**, *J. Opt. Soc. Amer.* **63**, No. 12, 1552-1555 (Dec. 1973).

Key words: dye laser; intra-cavity absorption; iodine detection; laser quenching; trace absorption detection; visible molecular absorption.

The enhancement of the detectability for trace absorptions by placing samples inside the laser cavity was found to be a factor of 100 for a flash-lamp-pumped dye laser and one thousand for a cw dye laser. High-resolution spectra showed that the holes in the laser output were as narrow as the absorptions that caused them. An approximately linear relationship (rather than the step-function behavior often associated with threshold phenomena) exists between pressures necessary to produce visually identical absorption spectra from samples placed inside and outside of the laser cavity. If such a relationship is of general occurrence, it will greatly facilitate the use of intracavity absorption for quantitative analysis, determination of relative absorption cross section, and for the study of the kinetics of appearance and disappearance of transient species.

- 13862.** Moore, L. J., Moody, J. R., Barnes, I. L., Gramlich, J. W., Murphy, T. J., Paulsen, P. J., Shields, W. R., **Trace determination of rubidium and strontium in silicate glass standard reference materials**, *Anal. Chem.* **45**, No. 14, 2384-2387 (Dec. 1973).

Key words: isotope dilution; mass spectrometry; rubidium; standards; strontium; trace analysis.

Procedures have been developed for the accurate trace analysis of Rb and Sr by mass spectrometric isotope dilution. A new Sr isotopic assay technique capable of measuring the three abundant Sr isotopes to <0.05 percent (ts) was combined with recently available high purity reagents and absolute standards to produce accurate and reliable analytical techniques. Application of these techniques to the determination of Rb and Sr in silicate glass standard reference materials has resulted in accuracies within <0.25 percent at the ppm ( $\mu\text{g/g}$ ) level and within <0.6 percent at the ppb (ng/g) level.

- 13863.** Smith, E. W., Cooper, J., Chappell, W. R., Dillon, T., **An impact theory for Doppler and pressure broadening—I. General theory**, *J. Quant. Spectrosc. Radiat. Transfer* **11**, 1547-1565 (1971).

Key words: molecular collisions; scattering theory; spectral line widths.

A quantum-mechanical impact theory for the combined effects of Doppler and pressure broadening is developed from quantum radiation theory. The results are compared with other semiclassical theories and certain simplifying approximations relevant to cases of experimental and theoretical interest are discussed.

- 13864.** Smith, E. W., Cooper, J., Vidal, C. R., **Comments on the validity of the unified classical path theory of Stark broadening**, *J. Phys. B* **5**, L33-L35 (1972).

Key words: electron gas; Stark broadening; unified theory.

In a recent paper by Frisch and Brissaud certain aspects of the unified classical path theory for Stark broadening are criticized; since we feel that their results could be misleading, we offer some comments on their paper.

- 13865.** Vidal, C. R., **Spectroscopic observations of subsonic and sonic vapor flow inside an open-ended heat pipe**, *J. Appl. Phys.* **44**, No. 5, 2225-2232 (May 1973).

Key words: heat pipe oven; resonance fluorescence spectra; sonic flow.

Spectroscopic measurements of the vapor flow velocities inside a heat-pipe oven have been performed as a function of pressure, heater power, and radial position inside the pipe. For this purpose the relative intensity of the collision-induced satellite lines in laser-induced resonance fluorescence spectra of the  $^7\text{Li}_2$  molecule has been employed. A one-dimensional flow model is presented which determines the vapor parameters as a function of position along the pipe. It predicts the onset of the sonic flow which has been verified experimentally. A criterion is derived from which the parameters of the vapor can be obtained from the ideal gas relation, neglecting velocity-dependent terms.

- 13866.** Smith, E. W., Cooper, J., Chappell, W. R., Dillon, T., **An impact theory for Doppler and pressure broadening—II. Atomic and molecular systems**, *J. Quant. Spectrosc. Radiat. Transfer* **11**, 1567-1576 (1971).

Key words: molecular collisions; scattering theory; spectral line widths.

A semiclassical theory for Doppler and pressure broadening in neutral gases is derived as a limiting case of a more general quantum mechanical theory. This theory is compared with other semiclassical theories and methods of calculation are discussed.

- 13867.** Smith, E. W., Cooper, J., Roszman, L. J., **An analysis of the unified and scalar additivity theories of spectral line broadening**, *J. Quant. Spectrosc. Radiat. Transfer* **13**, 1523-1538 (1973).

Key words: relaxation theory; scalar additivity theory; spectral line broadening; unified theory.

A new derivation of both unified and scalar additivity theories is given. This derivation concentrates on their regions of validity and certain key differences are analyzed in detail.

- 13868.** Nelson, C. A., Steele, D., **Symmetry relations among pionization cross sections**, *Phys. Rev. D* **8**, No. 9, 2908-2915 (Nov. 1, 1973).

Key words: inclusive reactions; pionization region; quark model; Regge residue; SU(3); symmetry relations.

From Mueller's Regge analysis of the *pionization region*, symmetry relations to order  $s^{-1/4}$  among invariant cross sections at  $x=0$ , in which a final pion is observed, are derived. SU(3) and quark universality are assumed to relate the Regge residues at the projectile-Reggeon vertex. There is good agreement with experiment to 10–15 percent indicating that the approximate symmetry pattern at nonasymptotic energies is that of total cross sections. The rising of the invariant cross sections to their asymptotic forms as  $c - bs^{-1/4}$  can be understood in terms of known  $j$ -plane singularities if the  $f$ -Pomeron central vertex  $g_{fp}^{\pi^+}$  ( $q_{\perp}^2$ ) < 0. Symmetry relations valid for final kaons and nucleons and for both the pionization and the target-fragmentation regions are also given.

- 13869.** Morrissey, B. W., McCrackin, F. L., Stromberg, R. R., **Determination of distributions in inhomogeneous films**, *J. Colloid Interface Sci.* **42**, No. 1, 198-200 (Jan. 1973).

Key words: attenuated total reflection; distributions; ellipsometry; inhomogeneous films.

The distribution of material in an inhomogeneous film is an important parameter in many problems. By representing the inhomogeneous film as a stack of thin homogeneous films, we have developed a method for utilizing concomitant ellipsometric and



attenuated total reflection measurements to determine the distribution of films whose thickness can be modified stepwise. We have compared our method to that of Beckman and Harrick, using their data for SiH impurity within an SiO<sub>2</sub> film. For two distributions, an exponential and a Gaussian, our method produced good fits with an accuracy limited only by the incremental thickness used for the calculations. Application of the method of Beckmann and Harrick yielded less accurate results which can also show artificial minima in the distribution.

**13870.** Hunt, C. M., **An analysis of roll filter operation based on panel filter measurements**, *ASHRAE Trans.* **78**, Part 2, 227-234 (1972).

Key words: air conditioning filters; air filters; particulate filters; roll filters.

The pressure drop across an air filter can usually be expressed as a linear function of the face velocity in a log-log plot. This is true for both clean and dirty filters. Use of this fact has been made to develop a descriptive model to predict the dust holding capacity of a roll filter from parameters measured with a panel filter of the same medium when the movement of the roll filter is controlled by a pressure switch. The model is applied to some test data obtained with a panel filter to explore the possible effect of varying pressure switch settings, air velocity, and other parameters on the predicted performance of a roll filter.

**13871.** Berger, M. J., **Beta-ray dose in tissue-equivalent material immersed in a radioactive cloud**, *Health Phys.* **26**, 1-12 (Jan. 1974).

Key words: beta-rays; depth-dose; dosimetry; electrons; immersion problem; radioactive cloud.

The radioactive-cloud immersion problem for beta-radiation has been treated schematically by assuming a semi-infinite air medium (source region) located adjacent to a semi-infinite water medium (tissue-equivalent target). The source region has been assumed to contain a uniform concentration of beta-emitting radionuclide, and calculations have been made of the absorbed-dose distribution (depth dose) in the water target. A leakage correction has also been made to estimate the reduction of absorbed dose that would occur if the target had lateral dimensions small compared to the beta-particle range in air. Depth-dose calculations have been carried out for various source spectra (including beta-ray as well as discrete electron spectra) for 15 radionuclides (rare gases) emitted by nuclear power plants into the atmosphere, and for 12 other commonly used radionuclides.

**13872.** Gubser, D. U., Soulen, R. J., Jr., **Thermodynamic properties of superconducting iridium**, *J. Low Temp. Phys.* **13**, No. 3/4, 211-226 (1973).

Key words: critical magnetic field; iridium; superconductivity; transition temperatures.

The superconducting transition temperature of pure Ir is found to be 0.1125 K ( $\pm 0.0005$  K). The critical magnetic field as a function of temperature  $H_c(T)$  has also been measured. From these data it is determined that  $H_c(0)$  is 16.00 G (1 G corresponds to  $10^{-4}$  T),  $(dH_c/dT)_{T=T_c}$  is 235 G/K, the linear coefficient of normal state electronic specific heat  $\gamma$  is 3.19 mJ/mole-K<sup>2</sup>, and the energy gap anisotropy parameter  $\langle a^2 \rangle$  is 0.048. This value for  $\langle a^2 \rangle$  is the largest of any superconducting element so far observed, and its significance in determining the superconducting properties of Ir is discussed. By using the large supercooling effects noticed near  $T_c$ , the Ginzburg-Landau parameter  $\chi_0$  is found to be  $8.6 \times 10^{-3}$ . The effects of impurities on  $T_c$  and on the magnetic behavior of Ir are also discussed.

**13873.** Blevin, W. R., **Sinusoidal radiation chopper**, *Appl. Opt.* **12**, No. 12, 2802 (Dec. 1973).

Key words: radiation chopper; sinusoidal modulation.

A description is given of a simple method for modulating a beam of optical radiation sinusoidally.

**13874.** Dickens, B., Prince, E., Schroeder, L. W., Brown, W. E., **Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub>, a crystal structure containing unusual hydrogen bonding**, *Acta Crystallogr.* **B29**, Part 10, 2057-2070 (Oct. 1973).

Key words: calcium phosphate; centered hydrogen bonds; hydrogen bonding; single crystal neutron diffraction; single crystal x-ray diffraction.

Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub> crystallizes in the triclinic unit cell  $a = 7.5577$  (5),  $b = 8.2531$  (6),  $c = 5.5504$  (3) Å,  $\alpha = 109.87$  (1)°,  $\beta = 93.68$  (1)° and  $\gamma = 109.15$  (1)° at 25 °C with  $Z = 2$ . The structure was determined by an automated  $\Sigma_2$  method from x-ray data and refined by least-squares analysis to  $R_w(F) = 0.048$ ,  $R(F) = 0.020$  using 3678 observed x-ray data and to  $R_w(F) = 0.055$ ,  $R(F) = 0.048$  using 843 observed neutron data. Corrections were made for absorption, isotropic secondary extinction and anomalous dispersion in the x-ray case and for anisotropic secondary extinction in the neutron case. Least-squares refinements proceeded to the limits of the data sets in space group  $P\bar{1}$ . Rudimentary chains  $\text{Ca} \cdots [\text{P}(1)\text{O}_4] - \text{H}(1) \cdots [\text{P}(2)\text{O}_4] \cdots$  run parallel to  $[1\bar{1}0]$ . Adjacent chains are joined by  $\text{Ca} \cdots \text{O}$  bonds on one side and by  $\text{O}(8) - \text{H}(5) - \text{O}(8')$  hydrogen bonds on the other. Alternatively, the structure may be considered to contain hydrogen-bonded layers of PO<sub>4</sub> groups; these layers are held together by hydrogen bonds on one side and by  $\text{Ca} \cdots \text{O}$  bonds on the other. There are two very strong hydrogen bonds in the structure;  $\text{O}(7) - \cdots \text{H}(4) - \cdots \text{O}(7')$ ,  $\text{O}(7) \cdots \text{O}(7') = 2.434$  (2) Å and  $\text{O}(8) - \cdots \text{H}(5) - \cdots \text{O}(8')$ ,  $\text{O}(8) \cdots \text{O}(8') = 2.423$  (2) Å. These hydrogen bonds join the P(2)O<sub>4</sub> groups together to form an infinite chain. The very strong hydrogen bonds are across nominal centers of symmetry, and diffraction results indicate that each of the H(4) and H(5) protons is effectively centered in a broad symmetric potential well, possibly with a central barrier. A combination of diffraction and infrared spectral considerations suggests that the central barriers in the wells, if they exist, probably lie below the zero-point energy of the hydrogens.

**13875.** Currie, L. A., **The evaluation of radiocarbon measurements and inherent statistical limitations in age resolution**, (Proc. 8th International Conference on Radiocarbon Dating, Wellington, New Zealand, Oct. 18-25, 1972), Paper in *Proceedings 8th International Conference on Radiocarbon Dating*, T. A. Rafter and T. Grant-Taylor, Eds., 2, 598-611 (Royal Society of New Zealand, Wellington, New Zealand, 1973).

Key words: age resolution; extraneous random errors; factor of merit components; method performance characteristics; minimum and maximum detectable ages; radiocarbon dating; statistical limitations.

A uniform approach, based upon the statistical behavior of random measurement errors, is suggested for assessing the relative merit of alternative methods of measuring radiocarbon and for interpreting and reporting the results of such measurements. The need for an objective, uniform approach is manifest because of the increasing concern with results which are close to the limits of precision or detection of the dating procedures.

The standard deviation of the estimated net signal (sample counts) is first examined in terms of its dependence upon random errors arising in observations of background and gross sample counts. Because of the high precision characterizing such observations, it becomes vital to evaluate random errors additional to the Poisson (counting) errors. The ability to discriminate between samples of similar age, and minimum and maximum detectable ages are discussed in terms of the statistical theory of hypothesis testing. An explicit approach results for the uniform treatment of detection, detectability and age limits.

The performance characteristics of alternative measurement



methods cannot simply be stated in terms of a single "figure of merit," because of the rather complex dependence upon counting times, sample, background and modern standard counting rates, and non-Poisson sources of random errors. A "reduced activity" (sample activity/background equivalent activity) plot is offered as a means for planning experiments and for rapidly assessing the capabilities of any specific measurement procedure. As a result of the particular choice of variables for this plot, alternative procedures may be represented by points in a fixed, two-dimensional array, where simple translations of the entire array correspond to changes in counting time or sample age.

- 13876.** Colson, J. P., Reneker, D. H., **Growth direction of polyoxymethylene crystals inside irradiated trioxane crystals**, *J. Appl. Phys.* **44**, No. 10, 4293-4302 (Oct. 1973).

Key words: electret domains; polyoxymethylene crystals; radiation damage; solid state polymerization; trioxane.

The long slender crystals of polyoxymethylene that grew in irradiated trioxane crystals all grew toward the negative end of the trioxane crystal. The observed direction of growth was consistent with the assumption that the ion at the growing end of the polyoxymethylene chain was a cation. Certain morphological features such as facets and direction of taper of these polyoxymethylene crystals indicated the direction in which the crystals grew. Incidental observations of polyoxymethylene precursor crystals, electret domains in trioxane, and the effects of electron irradiation on polyoxymethylene crystals were made.

- 13877.** Wiese, W. L., **Arc plasmas as radiation standards in the vacuum ultraviolet**, (Proc. VI Yugoslav Symp. and Summer School on the Physics of Ionized Gases, Miljevac by Split, Yugoslavia, July 16-21, 1972), Paper in *Physics of Ionized Gases*, M. V. Kurepa, Ed., pp. 597-625 (Institute of Physics, Beograd, Yugoslavia, 1972).

Key words: hydrogen arc plasma; radiation standard; radiometric calibrations; vacuum ultraviolet.

The principle of using arc plasmas as radiation standards in the vacuum ultraviolet is described, and it is shown that a hydrogen

arc plasma has particularly suitable properties due to the fact that its atomic radiation constants are exactly known. The calibration work with a hydrogen arc plasma at NBS is discussed, and preliminary results with this recently established facility are presented.

- 13878.** Hougén, J. T., **A modified ladder operator formalism for molecule-fixed components of the total angular momentum operator in linear molecules**, *J. Mol. Spectrosc. Notes* **48**, No. 3, 609-611 (Dec. 1973).

Key words: commutation relations; Eulerian angles; ladder operators; linear molecules; molecule-fixed components; total angular momentum.

Because molecule-fixed components of the total angular momentum operator for linear molecules do not obey angular momentum commutation relations (either with or without the anomalous sign of  $i$ ), the traditional angular momentum ladder operator formalism cannot be applied. It is known that this difficulty can be overcome by introducing into the linear molecule problem an extra rotational angle, which has no physical significance, but which does lead to a formalism isomorphic with the normal formalism for nonlinear molecules. It is shown that the linear molecule angular-momentum problem is susceptible to treatment, without introduction of an extraneous variable, by a relatively straightforward extension of the conventional formalism, in which angular momentum operators are taken to be functions of an integral or half-integral parameter representing the projection of the total angular momentum along the linear axis.

- 13879.** Vidal, C. R., Cooper, J., Smith, E. W., **Hydrogen Stark-broadening tables**, *Astrophys. J. Suppl. Ser.* **25**, No. 214, 37-135 (Jan. 1973).

Key words: Stark broadening of hydrogen.

Tables of Stark broadening of the first four Lyman lines and the first four Balmer lines of hydrogen are presented. They are based on a recently developed "unified theory" of line broadening which generates normalized profiles covering the entire profile from the impact limit in the line center to the quasi-static

limit in the line wings. The tables are presented in a convenient form for accurate numerical interpolation.

**13880-13893.** Unassigned.

**13894.** Kearsley, E. A., **Measurement of normal stress by means of hole pressure**, *Trans. Soc. Rheol.* **17**, No. 4, 617-628 (1973).

Key words: hole pressure; normal stress; pressure hole errors; shearing flows.

A measurement of normal stress differences in a shearing elastic liquid is accomplished through direct measurement of hole pressure. Gravity flow down an inclined channel is used and hole pressure is measured for slots perpendicular and parallel to the flow, as well as for a circular hole. The first and second normal stress differences are calculated under the assumption of second-order fluid behavior. Dynamic data are compared and a discrepancy noted.

**13895.** Hardy, S. C., Coriell, S. R., **Surface tension and interface kinetics of ice crystals freezing and melting in sodium chloride solutions**, *J. Cryst. Growth* **20**, 292-300 (1973).

Key words: crystal growth; ice; interface kinetics; morphological stability; sodium chloride; surface tension.

Cylindrical ice crystals growing into supercooled 0.1 M sodium chloride solutions develop approximately sinusoidal perturbations parallel to the cylinder axis. Using a previously developed non-linear morphological stability theory, an analysis of the growth and melting rates of these perturbations yields values of the solid-liquid surface tension and linear interface kinetic coefficient. In contrast to previous results in 0.1 M hydrochloric acid solutions, the melting behavior in sodium chloride solutions is different from the growth behavior. From the growth data, the solid-liquid surface tension is 30 mJ/m<sup>2</sup> and the linear interface kinetic coefficient is  $2.2 \times 10^{-4}$  m/s K for solutions with pH > 6. For solutions with pH < 5.5 and for all solutions on melting, the kinetic coefficients is too large ( $> 10^{-3}$  m/s K) to measurably affect the perturbation velocities. From the melting data, the surface tension is 38 mJ/m<sup>2</sup>. The difference

in surface tension on melting and growth is attributed to ionic adsorption during growth. Experiments in which the crystal is grown in one solution and is melted in a different solution indicate that the surface tension depends on the chloride content of the ice.

**13896.** Ferguson, E. E., Fehsenfeld, F. C., Phelps, A. V., **Comment on photodetachment cross sections for CO<sub>3</sub><sup>-</sup> and its first hydrate**, *J. Chem. Phys.* **59**, No. 3, 1565-1566 (Aug. 1, 1973).

Key words: CO<sub>3</sub><sup>-</sup>; negative ions; photodetachment cross section; photodissociation.

Burt recently reported the photodetachment threshold energies for  $\text{CO}_3^- + h\nu \rightarrow \text{CO}_3 + e$  and  $\text{CO}_3^- \cdot \text{H}_2\text{O} + h\nu \rightarrow \text{CO}_3 \cdot \text{H}_2\text{O} + e$  to be 1.8 and 2.1 eV, respectively. It can be shown from previously established thermochemistry that these reported threshold energies are substantially too low unless the dissociation energy  $D(\text{CO}_2 - \text{O})$  is much larger ( $> 1.5$  eV) than has been previously reported.

**13897.** Julienne, P. S., **Nonadiabatic effects in the B, C, B', and D states of H<sub>2</sub>**, *J. Mol. Spectrosc.* **48**, No. 3, 508-529 (Dec. 1973).

Key words:  $\Lambda$ -doubling; heterogeneous interaction; molecular hydrogen; nonadiabatic; pure precession; RKR potentials.

The Kolos-Wolniewicz potentials for the H<sub>2</sub> B'<sup>1</sup> $\Sigma_u^+$  and C'<sup>1</sup> $\Pi_u$  states were used together with the hypothesis of pure precession for the rotation-electronic interaction, to calculate the nonadiabatic energy levels of these states for  $J=1$  to 5. The complete coupling matrix was computed using accurate numerical vibrational wavefunctions. The calculated  $\Lambda$ -doubling of the  $v=0$  to 12 C vibrational levels generally agrees well with experimental values, and the nonadiabatic shifts in the B rotational constants qualitatively explain the difference between the theoretical and RKR potentials for this state.

The interaction of the B' <sup>1</sup> $\Sigma_u^+$  and D <sup>1</sup> $\Pi_u$  states was also in-



vestigated, but only qualitatively since adiabatic potentials of sufficient accuracy do not exist for these states. The  $\Lambda$ -doubling of the  $Dv=0$  rotational levels agrees well with the experimental values. An appreciable "background" nonadiabatic shift in the  $B'$  rotational constants was found. This shift, which is nearly 5 percent of  $B_v$ , is in addition to that of strong local two-level interactions and was not "deperturbed" in constructing the  $B'$  RKR potential. The result is that the RKR turning points differ by about 0.04 au from the "true" adiabatic turning points. This conclusion is supported by a Hartree-Fock calculation of the  $B'$  potential to the left of  $R_e$ .

- 13898.** Lowke, J. J., Phelps, A. V., Irwin, B. W., **Predicted electron transport coefficients and operating characteristics of CO<sub>2</sub>-N<sub>2</sub>-He laser mixtures**, *J. Appl. Phys.* **44**, No. 10, 4664-4671 (Oct. 1973).

Key words: attachment coefficient; CO<sub>2</sub> cross sections; CO<sub>2</sub> laser; electron distribution; electron transport; ionization coefficient.

Calculations have been made of transport coefficients of electrons in gas mixtures for ratios CO<sub>2</sub>:N<sub>2</sub>:He of 1:1:8, 1:2:3, 1:7:30, and 1:0.25:3. New cross sections for CO<sub>2</sub> derived from swarm experiments are used together with previously published cross sections for N<sub>2</sub> and He. Curves are presented of the predicted electron drift velocity, transverse and longitudinal diffusion coefficients, and ionization and attachment coefficients for  $E/N$  values ranging from  $10^{-18}$  to  $1 \times 10^{-15}$  V cm<sup>2</sup>;  $E$  is the electric field strength and  $N$  the gas number density. Examples are given of derived distribution functions and comparisons are made with a Maxwellian distribution function. The percentage of the input electrical power which excites vibrational processes coupled to the 001 upper laser level of CO<sub>2</sub> is given as a function of  $E/N$ . The maximum efficiency from these calculations increases for increasing ratios of N<sub>2</sub>:CO<sub>2</sub>, because the proportion of energy used to excite the bending and stretching modes of CO<sub>2</sub> is then reduced. By assuming a recombination coefficient of  $10^{-7}$  cm<sup>3</sup> sec<sup>-1</sup>, the operating  $E/N$  for self-sustained glow discharges is predicted as a function of current density for various laser mixtures by equating the ionization rate to the attachment and recombination rate.

- 13899.** Reimer, G. M., Carpenter, B. S., **Thorium determination in glasses using fission track technique**, *Nature* **247**, 101-102 (Jan. 11, 1974).

Key words: fast flux; fission track technique; thorium determination; Th/U ratio; track excess.

The fission track technique has been applied for the determination of thorium in glasses. Two irradiations are performed. The first is with a thermalized flux to determine the uranium content by fission of <sup>235</sup>U. The second irradiation is with a fast flux to induce fission of thorium in addition to uranium. By comparing track counts of both irradiations to a uranium standard, the "track excess" of the second irradiation is related to the thorium content. The accuracy is dependent on the Th/U ratio. The uncertainty for the Th/U ratio of 4 is approximately 20 percent and increases as the ratio decreases.

- 13900.** Jennings, D. A., Braun, W., Broida, H. P., **Vibrational relaxation of hydrogen by direct detection of electronic and vibrational energy transfer with alkali metals**, *J. Chem. Phys.* **59**, No. 8, 4305-4308 (Oct. 15, 1973).

Key words: apparatus; energy transfer; metals; method; photochemistry; resonance fluorescence; vibrational relaxation.

A technique has been developed to measure the rate constant for vibrational relaxation of H<sub>2</sub><sup>v=3,4</sup> by H<sub>2</sub><sup>v=0</sup>. The technique uses a mechanically chopped, tunable, cw dye laser coincident with either of the Na resonance lines at 589.6 or 589.0 nm. Sodium

vapor is contained in a glass cell along with Cs atoms and H<sub>2</sub>. Sodium atoms, excited by the dye laser radiation, collisionally transfer electronic energy to H<sub>2</sub> producing some H<sub>2</sub><sup>v</sup>. Only vibrational energy in H<sub>2</sub><sup>v</sup> from levels  $v=3,4$  can transfer to Cs as electronic energy and cause Cs resonance line emission at 894 and 852 nm. In this manner, using the observed emission as a detector of H<sub>2</sub><sup>v=3,4</sup>, the vibrational relaxation rate constant was determined to be  $3.9 \times 10^{-14}$  cm<sup>3</sup> sec<sup>-1</sup>. Similar rate constants were measured, with somewhat less accuracy, for D<sub>2</sub><sup>v</sup> colliding with D<sub>2</sub> and for H<sub>2</sub><sup>v</sup> colliding with He. It was found that N<sub>2</sub>, Na, and Cs also undergo electronic to vibration and vibration to electronic energy exchange.

- 13901.** Davis, D. D., Klemm, R. B., Braun, W., Pilling, M., **A flash photolysis-resonance fluorescence kinetics study of ground-state sulfur atoms. II. Rate parameters for reaction of S(<sup>3</sup>P) with C<sub>2</sub>H<sub>4</sub>**, *Int. J. Chem. Kinet.* **4**, 383-394 (1972).

Key words: chemistry; ethylene; flash-photolysis; kinetics; resonance-fluorescence; sulfur atoms.

Absolute rate constants for the reaction of S(<sup>3</sup>P) with ethylene were measured over an ethylene concentration range of 7, a total pressure of 50 to 400 torr, and a flash intensity range of 10. At 298 °K, the bimolecular rate constant was found to be invariant over this range of variables and had a measured value of  $4.96 \times 10^{-13}$  cm<sup>3</sup> molec<sup>-1</sup> s<sup>-1</sup>. Over the temperature range of 218° to 442 K, the rate data could be fit to a simple Arrhenius equation of the form

$$k_1 = (7.13 \pm 0.74) \times 10^{-12} \exp \left( \frac{-1.58 \pm 0.08 \text{ kcal/mole}}{RT} \right).$$

Units are cm<sup>3</sup> molec<sup>-1</sup> s<sup>-1</sup>. The dependence of the measured value of  $k_1$  on the concentration of the reaction product ethylene episulfide is discussed.

- 13902.** Colwell, J. H., **Thermal contacts in a low temperature cryostat**, *Cryogenics* **13**, No. 11, 674-675 (Nov. 1973).

Key words: cryogenics; electrical leads; low temperature; thermal conductivity; thermal contact.

The thermal conductances of an assembly used for thermally anchoring electrical leads in a low temperature cryostat are reported. Measurements were made between 0.3 and 4 K of the conductance across the contacts of miniature gold-plated electrical connectors, insulated copper wires varnished to a copper mounting, and its copper mounting bolted to a copper support.

- 13903.** Lide, D. R., Jr., Rossmassler, S. A., **Status report on critical compilation of physical chemical data**, *Annu. Rev. Phys. Chem.* **24**, 135-158 (1973).

Key words: compilation; critical evaluation; data; NSRDS; physical chemistry; reference data; status report.

The significance of data evaluation and the importance of sources of reliable reference data are pointed out. A review is provided of major past and present data compilation activities of interest to physical chemists, including early efforts (before 1930); isolated programs in the period 1930-1960; the National Standard Reference Data System; other government and non-government programs; other national programs; and international programs. A rationale and discussion of methodology of data evaluation are presented with brief illustrations. Finally, three types of data sources are listed: systematic publication series, data centers, and recent compendia.

- 13904.** Mauer, F. A., Hubbard, C. R., Hahn, T. A., **Thermal expansion and low temperature phase transition of thallous azide**, *J. Chem. Phys.* **59**, No. 7, 3770-3776 (Oct. 1, 1973).

Key words: bond method; phase transition; thallous azide; thermal expansion.



Thallous azide,  $\text{TiN}_3$ , is tetragonal at room temperature. It transforms at  $248 \pm 5$  K to a phase that can be indexed on the basis of an orthorhombic cell. Lattice parameters of the tetragonal phase have been determined by the Bond single crystal method at intervals of approximately 25 K from 248 to 498 K. Single crystals do not survive the transition, so the parameters of the orthorhombic phase were measured by powder diffraction at intervals of 25 K down to 133 K. Representative parameters, after corrections for the effects of radiation damage, are  $a = 6.2094$  Å,  $c = 7.3583$  Å at 298.2 K for the tetragonal phase, and  $a = 8.718$  Å,  $b = 8.766$  Å,  $c = 7.395$  Å at 238.2 K for the orthorhombic. Thermal expansion parameters show anomalies that are believed to be the result of changes in the orientation of azide ions. The linear expansion coefficients,  $\alpha_a$  and  $\alpha_c$ , for the tetragonal phase are both approximately  $5.2 \times 10^{-5} \text{ K}^{-1}$  at the transition. By 486 K,  $\alpha_c$  has increased to  $21 \times 10^{-5} \text{ K}^{-1}$  and  $\alpha_a$  has decreased to  $-1.2 \times 10^{-5} \text{ K}^{-1}$ . For the orthorhombic phase  $\alpha_b$  remains constant at  $5.2 \times 10^{-5} \text{ K}^{-1}$  while  $\alpha_a$  increases from  $10 \times 10^{-5} \text{ K}^{-1}$  to  $22 \times 10^{-5} \text{ K}^{-1}$  and  $\alpha_c$  decreases from  $-1.5 \times 10^{-5} \text{ K}^{-1}$  to  $-11 \times 10^{-5} \text{ K}^{-1}$  in the temperature range 150 to 225 K. There does not appear to be a discontinuity in the volume at the transition. The volume expansion coefficient is approximately  $17 \times 10^{-5} \text{ K}^{-1}$  for the orthorhombic phase and  $15 \times 10^{-5} \text{ K}^{-1}$  for the tetragonal.

- 13905.** Kirchhoff, W. H., Johnson, D. R., Powell, F. X., **Centrifugal distortion effects in  $\text{SF}_2$ : Calculation of the force field and infrared spectrum**, *J. Mol. Spectrosc.* **48**, No. 1, 157-164 (Oct. 1973).

Key words: centrifugal distortion; force field; microwave spectrum;  $\text{SF}_2$ ; structure; vibrational fundamental.

Measurements of the microwave spectrum of  $\text{SF}_2$  have been extended up to  $J = 43$  in order to account for the effects of centrifugal distortion. Seventy-five transitions have been included in a weighted least squares fit of the measured spectrum with an rms deviation of 0.078 MHz. The force field for  $\text{SF}_2$  has been determined from the centrifugal distortion constants. The vibrational spectrum, as yet unobserved, has been predicted from the force field as have been the Coriolis coupling constants and the average structure.

- 13906.** Thomas, R. N., **Suggested interpretation of the correlations in intensity fluctuations in the lines Ca II H and K, magnesium b, and hydrogen H $\beta$** , *Solar Phys.* **27**, 303-304 (Dec. 1972).

Key words: intensity fluctuations; solar spectral lines.

In the preceding note, Evans and Catalano have found interesting behavior in the correlation between intensity fluctuations in the continuum and in the lines H and K of Ca II, b1 and b2 of MgI, and hydrogen H $\beta$ . In the first four lines, the correlation drops smoothly from  $\sim 0.9$  near the continuum to negative values; followed by a rise to about zero at line center. For H, the correlation is never negative, reaching zero at about 0.25 Å.

We suggest that this behavior reflects a combination of effects. First the source-sink terms in the source-functions depend on different physical parameters in the two sets of lines. In addition, the line center regions are dominated by transfer effects at the top of the atmosphere.

- 13907.** Billingsley, F. P. II, **Calculation of the absolute infrared intensities for the 0-1, 0-2 and 1-2 vibration-rotation transitions in the ground state of  $\text{NO}^+$** , *Chem. Phys. Lett.* **23**, No. 2, 160-166 (Nov. 15, 1973).

Key words: dipole moment function; infrared intensities; multiconfiguration;  $\text{NO}^+$ .

The absolute infrared intensities of the 0-1, 0-2 and 1-2 vibration-rotation bands in the  $\Sigma^+$  ground state have been calculated from first principles. The dipole moment function for  $\text{NO}^+$  was determined in the region of the equilibrium internuclear separa-

tion by an accurate multi-configuration self-consistent-field procedure. The dipole matrix elements over vibration states were solved exactly using numerical techniques. The ratio of the calculated integrated absorption coefficients for the fundamental and first overtone ( $88.8 \text{ cm}^{-2} \text{ atm}^{-1}$  and  $0.6 \text{ cm}^{-2} \text{ atm}^{-1}$ , respectively, at 273.16 K) is in reasonable agreement with an estimate based on observation of these bands in  $\text{NO}^+$  at high altitudes in the upper atmosphere.

- 13908.** Cassidy, E. C., Anderson, W. E., Booker, S. R., **Recent refinements and developments in Kerr system electrical measurement techniques**, *IEEE Trans. Inst. Meas.* **IM-21**, No. 4, 504-510 (Nov. 1972).

Key words: electric fields; electrical measurements; electro-optics; high-speed photography; high-speed techniques; high-voltage measurements; Kerr effect; laser applications.

Kerr system electrical measurement techniques are improved by progress in two important areas: 1) in the development of methods for visualizing and measuring pulsed (microsecond) electric fields and high voltages from time-varying electro-optical fringe patterns recorded using high-speed photographic techniques, and 2) in the development of convenient experimental methods for evaluating and correcting path-dependent errors in Kerr system response. Results demonstrate use of fringe-pattern measurements in achieving accurate pulse voltage measurements and in correction of errors resulting from sizeable end-field variations in existing 300-kV Kerr cells.

- 13909.** Jacob, E. J., Lide, D. R., Jr., **Structural implications of the microwave spectrum of hexafluoropropene**, *J. Chem. Phys.* **59**, No. 11, 5877-5881 (Dec. 1, 1973).

Key words: ground vibrational state; microwave spectrum of hexafluoropropene; rotational constants.

Analysis of the microwave spectrum of hexafluoropropene,  $\text{C}_3\text{F}_6$ , has yielded rotational constants for the ground vibrational state of 2557.88, 1255.033, and 987.082 MHz. Assignments have also been made on the first four excited states of the  $\text{CF}_3$  torsional mode and on the first excited state of another low-lying skeletal mode. A rough estimate of  $350 \text{ cm}^{-1}$  has been obtained for the barrier to internal rotation of the  $\text{CF}_3$  group. The ground-state moments of inertia are consistent with the expected geometry of the molecule, in which all atoms are coplanar except for two equivalent F atoms in the  $\text{CF}_3$  group.

- 13910.** Simmons, G. L., Eisenhauer, C., **Moments method calculations of neutron distributions in concrete**, *Nucl. Sci. Eng.* **53**, 197-219 (1974).

Key words: concrete; function fitting; moments; neutron transport; reactor shields; shielding.

The moments method is applied to the problem of calculating neutron distributions in an infinite medium. Several comparisons are given of these results with similar data calculated by the discrete ordinates method. New calculations are presented on the distribution of doses from neutrons, originating in a plane-slant fission source and incident, at various angles, on concrete utilized in radiation measurements at the Tower Shielding Facility of the Oak Ridge National Laboratory (TSF concrete). For a given set of neutron cross sections, these results give reliable estimates of the dose distribution at deep penetrations, i.e., attenuation of six orders of magnitude or more. Functional representations of the distributions are included in order to facilitate the use of the data in shield design calculations.

- 13911.** Rasberry, S. D., Heinrich, K. F. J., **Calibration for interelement effects in x-ray fluorescence analysis**, *Anal. Chem.* **46**, No. 1, 81-89 (Jan. 1974).

Key words: calibration; empirical calibration; iron-nickel-



chromium alloys; x-ray fluorescence; x-ray spectrochemical analysis.

A new empirical method for the calibration of x-ray fluorescence analysis in the presence of interelement effects is given. The effects of secondary fluorescence and of absorption are considered separately, with different expressions, in the calibration equation. The new approach is compared with empirical methods previously proposed by other authors, and is accurate and applicable over wide ranges of composition, even when the number of standards available is limited. An alloy system, in which the interelement effects are severe (Fe-Ni-Cr, over a range of composition from 0 to 100%), is studied experimentally; also evaluated are data, previously presented by other authors, for the calcium carbonate-silica system. With reference to 23 chemical determinations, in the two systems, the relative error is  $\pm 1$  percent or less in 13 instances and  $\pm 4$  percent or less in all but two determinations.

- 13912.** Hebner, R. E., Jr., Cassidy, E. C., **Measurement of 60 Hz voltages using the Kerr effect**, *Rev. Sci. Instrum.* **43**, No. 12, 1839-1841 (Dec. 1972).

Key words: electrical measurements; electro-optics; high voltage measurements; Kerr effect; laser applications; optical techniques.

The Kerr effect has been used to measure 60 Hz alternating voltage up to 30 kV peak. The system behaves much as it does under the influence of a short high-voltage pulse except that in this case the frequency of the applied voltage is sufficiently low that the space charge effects in the liquid are not negligible.

- 13913.** Bagus, P. S., Krauss, M., LaVilla, R. E., **The threshold region of the methane carbon K-absorption spectrum**, *Chem. Phys. Lett.* **23**, No. 1, 13-17 (Nov. 1, 1973).

Key words: carbon-K-absorption threshold; first Rydberg transition;  $1a_1^{-1}$  hole state calculation; methane; vibronic transition.

The carbon K-absorption of  $\text{CH}_4$  is analyzed with the help of an ab initio calculation of the Rydberg states of  $1a_1^{-1}$  hole state. The strong absorption peak at 288.3 eV is identified as the first Rydberg  $2t^* \leftarrow 1a_1$ , whose calculated ionization potential is in good agreement with experiment. Also, the oscillator strength for this transition was calculated to be  $f = 1.9 \times 10^{-2}$ , which is within the estimated margin of error of the experimental  $f = 0.6 \times 10^{-2}$ . The weak peak at 287.2 eV is interpreted as a vibronic transition to the  $3a_1(3s)$  Rydberg. An estimate of its oscillator strength as 10 percent of the allowed  $2t(3p)$  Rydberg line is consistent with experiment. For the case of  $\text{CD}_4$ , this weak forbidden transition was estimated to be 20 percent of the allowed  $2t(3p)$  Rydberg line.

- 13914.** Drullinger, R. E., Zare, R. N., **Optical pumping of molecules II. Relaxation studies**, *J. Chem. Phys.* **59**, No. 8, 4225-4234 (Oct. 15, 1973).

Key words: molecules; optical pumping.

The ( $v'' = 3, J'' = 43$ ) level of  $\text{Na}_2$  has been optically aligned using the 4880-Å line of a cw argon ion laser as a light source. The relaxation of this alignment is measured upon addition of foreign gas. In a low-pressure regime, where the mean free path exceeds the diameter of the light beam which both pumps and samples the alignment, the relaxation of the alignment versus pressure shows a "dog-leg shape" consisting of two linear regions. The first linear region corresponds to both elastic (velocity-changing) and inelastic (primarily rotational transfer) collisional relaxation whereas the second corresponds purely to inelastic collisional relaxation. The former process is dependent on the mode structure of the laser and shows saturation with increased pressure. In this low-pressure regime, the measured

cross sections are shown to be lower bounds to the true cross sections and excitation by a multimode laser is shown to be inequivalent to excitation by a white light source when the width of the holes in the velocity distribution of the absorber molecules are nonoverlapping.

- 13915.** Bass, A. M., Laufer, A. H., **The methyl radical combination rate constant as determined by kinetic spectroscopy**, *Int. J. Chem. Kinet.* **V**, 1053-1065 (1973); *Ber. Bunsenges. Phys. Chem.* **78**, No. 2, 198-200 (1974).

Key words: absorption spectroscopy; combination; f-number; methyl; radical; rate constant.

The rate constant for the reaction



has been determined by means of vacuum ultraviolet flash photolysis and time-resolved kinetic spectroscopic observations of the 1504-Å absorption band of  $\text{CH}_3$ . The measurements made using three different sources of methyl radicals (azomethane, dimethylmercury, and ketene-hydrogen) were in accord and yielded a value for the rate constant of  $k_1 = (9.53 \pm 1.17) \times 10^{-11}$  cc molec $^{-1}$  sec $^{-1}$ . A detailed error analysis is presented. The  $f$ -value for the 1504-Å band of  $\text{CH}_3$  is determined to be  $(2.5 \pm 0.7) \times 10^{-2}$ .

- 13916.** Chow, L. C., Brown, W. E., **Reaction of dicalcium phosphate dihydrate with fluoride**, *J. Dent. Res.* **52**, No. 6, 1220-1227 (Nov.-Dec. 1973).

Key words: calcium phosphates; dental caries; fluoride; fluorapatite; tooth enamel.

The intermediate formation of  $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$  and its subsequent conversion to  $\text{Ca}_5(\text{PO}_4)_3\text{F}$  or  $\text{CaF}_2$  may be a major factor in increased fluoride uptake when tooth enamel is pretreated with acid solutions before being exposed to fluoride. To obtain information concerning the form of fluoride incorporation, the reactions of  $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$  with solutions containing various amounts of  $\text{F}^-$  and  $\text{PO}_4^{3-}$  ions were studied.

- 13917.** Erez, A., **Low-frequency electrical signal measurement by electrooptical methods**, *IEEE Trans. Instr. Meas.* **IM-21**, No. 4, 358-360 (Nov. 1972).

Key words: electrooptical coupling; feedback amplifiers; light emitting diodes; photodetectors.

An analog system for the optical telemetry of voltage or current information using light-emitting diodes (LED) is described. Errors resulting from variations in the optical coupling efficiency are minimized because the light emitted by the LED contains the signal to be measured superimposed on a fixed intensity beam controlled by a reference zener diode. The nonlinearity of the LED is overcome by using part of its emitted light to control the feedback current of an operational amplifier that supplies the signal to the LED. The prototype system developed has a total error of approximately 0.2 percent of the input signal.

- 13918.** Cassidy, E. C., Hebner, R. E., **Experimental study of the behavior of nitrobenzene under varied high voltage conditions**, (Proc. Electrical Insulation and Dielectric Phenomena, Buck Hill Falls, Pa., Oct. 23-25, 1972), Chapter 1972 *Annual Report of the Conference Electrical Insulation and Dielectric Phenomena*, pp. 37-44 (National Research Council, National Academy of Sciences, Washington, D.C., 1973).

Key words: dielectric liquid; electrical properties of liquids; electro-optics; high voltage measurement; Kerr effect; laser applications; nitrobenzene; optical properties of liquids.

Recently developed fringe-pattern methods are employed for visualizing time and space variations in electric fields between electrodes immersed in nitrobenzene. Investigations are con-



ducted with operation under high direct, pulsed ( $\mu$ s), and 60 Hz voltage. With minimization of effects resulting from variations in the fringing fields at the electrode ends, the fringe-pattern "mappings" of the field distribution enable observation of space-charge behavior. Applied voltages are measured simultaneously using calibrated (with state-of-the-art accuracy) devices. Results enable computation and plotting of electric field distribution and intensity, of charge distribution, and of the Kerr constant of nitrobenzene.

- 13919.** Bur, A. J., Fetters, L. J., **Intrinsic viscosity measurements on rodlike poly(*n*-butyl isocyanate) and poly(*n*-octyl isocyanate)**, *Macromolecules* **6**, No. 6, 874-879 (Nov.-Dec. 1973).

Key words: intrinsic viscosity; poly(*n*-butyl isocyanate); poly(*n*-octyl isocyanate); rodlike.

Previous calculations of the molecular length of rodlike poly(*n*-butyl isocyanate),  $(-\text{CO}-\text{NC}_4\text{H}_9-)_n$ , from dielectric relaxation time measurements have not shown satisfactory agreement with the results from x-ray and light-scattering measurements. Here, we examine this conflict by extending our hydrodynamic experiments to include intrinsic viscosity measurements on well-characterized low molecular weight samples of poly(*n*-butyl isocyanate) (PBIC) and poly(*n*-octyl isocyanate) (POIC),  $(-\text{CO}-\text{NC}_8\text{H}_{17}-)_n$ . Using the Kirkwood-Auer-Riseman equation relating intrinsic viscosity and rod dimensions, the intermonomer translation along the rod axis is calculated to be  $1.66 \pm 0.12 \text{ \AA}$ . This is lower than the  $1.94\text{-\AA}$  result from x-ray measurements, but higher than the  $1.33 \pm 0.12 \text{ \AA}$  result from dielectric relaxation time measurements. The root of the problem appears to be the application of hydrodynamic equations to a physical situation which does not satisfy the model assumptions.

- 13920.** Evans, A. G., Fuller, E. R., **Crack propagation in ceramic materials under cyclic loading conditions**, *Met. Trans.* **5**, 27-33 (Jan. 1974).

Key words: ceramics; cyclic failure; relation to static failure; slow crack growth; tension/compression; time to failure.

An analysis is presented which enables crack propagation rates under cyclic loading conditions to be predicted from static slow crack growth parameters. A comparison of the predicted times to failure under cyclic conditions with available measured failure times, for several ceramic materials at ambient temperatures, suggests that there is no significant enhancement of the slow crack growth rate due to cycling. This is verified in a series of measurements of slow crack growth rates under static and cyclic conditions.

- 13921.** Cowan, D. O., LeVanda, C., Collins, R. L., Candela, G. A., Mueller-Westerhoff, U. T., Eilbracht, P., **Mössbauer and magnetic susceptibility studies of biferrocenylene (II, III) picrate**, *J. Chem. Soc. Chem. Commun.*, pp. 329-330 (1973).

Key words: biferrocenylene (2,3) picrate; magnetic susceptibility; Mössbauer.

Mössbauer and magnetic susceptibility studies of biferrocenylene (II, III) picrate show that extensive donor-acceptor interactions occur in this mixed-valence molecule which result in fractional oxidation states for the iron atoms.

- 13922.** Evans, A. G., Linzer, M., **Failure prediction in structural ceramics using acoustic emission**, *J. Amer. Ceram. Soc.* **56**, No. 11, 575-581 (Nov. 1973).

Key words: acoustic emission; ceramics; failure prediction; fracture.

Crack propagation in a typical structural ceramic (porcelain) is accompanied by acoustic emission. Two types of emission are

detected. The first type is caused by slow growth of the fracture-initiating flaw; the emission rate depends primarily on crack velocity. Failure prediction using this source of emission can be effective, however, only if low-level emission, which may be related exclusively to crack growth, can be detected. The second source of emission, which occurs during bulk stressing, is the cracking associated with second-phase particles (quartz particles in porcelain) as a result of the combined action of the applied stress and local thermal and mechanical stresses. An analysis for predicting emission rates is developed and forms the basis for using this source of acoustic emission in failure prediction.

- 13923.** Dragoo, A. L., Paule, R. C., **Ultrapur materials: Containerless evaporation and the roles of diffusion and Marangoni convection**, (Proc. 12th Aerospace Sciences Meeting, Washington, D.C., Jan. 30-Feb. 1, 1974), *AIAA Paper No. 74-209*, pp. 1-8 (American Institute of Aeronautics and Astronautics, New York, N.Y., 1974).

Key words:  $\text{Al}_2\text{O}_3$ ; complex equilibria; convective-diffusion; evaporative rate; purification (evaporative); solutal-capillary; thermal capillary convection; vacuum vaporization.

Contamination from containers is a major problem in preparing ultrapure refractory materials. Space with its zero gravity and its high vacuum offers an opportunity for containerless purification of these materials. The evaporation of impurities from a melt will involve many complex chemical equilibria. Thermodynamic calculations have been modified to describe these equilibria when impurities in the melt evaporate into vacuum. The contributions of diffusion and Marangoni convection to mass transfer rates in the bulk liquid have been estimated. Calculations for the evaporative purification of molten alumina are given.

- 13924.** Geist, J., Blevin, W. R., **Chopper-stabilized null radiometer based upon an electrically calibrated pyroelectric detector**, *Appl. Opt.* **12**, No. 11, 2532-2535 (Nov. 1973).

Key words: ac power measurements; electrically calibrated radiometer; pyroelectric detector; radiometer; radiometry.

In this paper we will describe a new type of radiometric system that combines the high-accuracy characteristics of electrical calibration and null detection with the noise and background discrimination of chopper-stabilized, synchronous detection. We start by outlining those characteristics required for high accuracy and those required for good noise discrimination. Next we show that these requirements are mutually inconsistent for certain types of detectors (thermopiles), but that they can all be well satisfied by electrically-calibrated pyroelectric detectors. Then we discuss the special requirements for a chopper-stabilized null radiometer, including wave-form independent, lock-in detection, and lastly we describe the performance of a system that we have constructed.

- 13925.** Geist, J., Schmidt, L. B., Case, W. E., **Comparison of the laser power and total irradiance scales maintained by the National Bureau of Standards**, *Appl. Opt.* **12**, No. 11, 2773-2776 (Nov. 1973).

Key words: intercomparison; irradiance scale; laser power scale.

The paper describes an intercomparison of the instrument used to realize and maintain the NBS laser power and energy scale with the instrument used to realize and maintain the upper end of the NBS total irradiance scale. The intercomparison was conducted by performing simultaneous measurements of the average power from a cw krypton laser with both instruments. The procedure and apparatus of the comparison are described. The measured difference between the two instruments was well



within the  $\sim 1.5$  percent limit of error associated with the inter-comparison.

- 13926.** McCarter, R. J., **A new technique for thermal analysis of vapor-producing reactions**, *J. Appl. Polym. Sci.* **17**, 1833-1846 (1973).

Key words: differential thermal analysis; DTA; kinetics; pyrolysis; TGA; thermal analysis; thermal degradation; thermogravimetric analysis.

An apparatus was developed for measuring the rate at which vapors are evolved during the thermal degradation of materials and thereby deriving the kinetics of such reactions. Requisite to the operating scheme of the apparatus is the provision of a high-temperature zone to convert condensable or tarry vapors into noncondensable form. The apparatus yields a direct measure of reaction velocity, rather than the integrated indication obtained with thermogravimetric analysis. This simplifies the identification and calculation of kinetic parameters. Increases in sensitivity and operating range are also achieved. Flexibility in operation is obtained that permits the separate recording of reactions that tend to overlap. Although the apparatus principally has been operated using a combustible gas indicator to meter the evolved vapors, a number of options are available for the latter function, including flowmeters and various continuous gas analyzers. The applicability of the method appears promising.

- 13927.** Unassigned.

- 13928.** Weiss, A. W., **Correlation in excited states of atoms**, *Advan. At. Mol. Phys.* **9**, 1-46 (1973).

Key words: correlation; energy levels; oscillator strengths; spectroscopy; wave functions.

This article reviews the current status of work on electron correlation in excited states of light atoms through approximately  $Z = 20$ . The primary orientation is towards *ab initio* correlation calculations, so that semiempirical methods are not discussed except insofar as they relate directly to the correlation problem. Furthermore, the discussion is restricted to the effects of correlation on only two properties, namely energies and oscillator strengths. After a brief statement and description of the correlation problem in general, we concentrate on 1) methods currently employed to attack excited state correlation, and 2) a description of some of the results obtained so far which appear to be peculiar to excited states.

Since most excited state correlation calculations have relied on the multiconfiguration expansion, this method is described at some length. For convenience the variety of such approaches are classified according to the choice of zeroth order, or reference state, starting point, which may be the Hartree-Fock, Hartree-Fock-Slater, or statistical model. Allowing the reference state orbitals to relax in the field of the virtual configuration leads to the multiconfiguration self-consistent field approximation, and this method is described as well. The charge expansion scheme and the pair correlation approach are also discussed from the standpoint of providing a framework for analyzing much of the results which have been obtained.

Some of the more striking effects of excited state correlation are related to the readjustment of energy levels along an isoelectronic sequence. Not only are there anomalies associated with level crossings, but the asymptotic degeneracy effects predicted by the charge expansion theory appear, very often, to persist along an entire sequence. One of the large correlation corrections in the ground state involves orbital polarization, and this also happens with excited states, where it can often be understood as a series perturbation phenomenon. Series perturbations represent a large and important correlation correction not only for the series but for the perturbing state as well. These effects are all discussed by way of examples. Finally, some discussion is given of the role of pair correlations in excited states.

- 13929.** Farabaugh, E. N., Parker, H. S., Armstrong, R. W., **Skew-reflection x-ray microscopy of the vapor-growth surface of an  $\text{Al}_2\text{O}_3$  single crystal**, *J. Appl. Crystallogr.* **6**, Part 6, 482-486 (Dec. 1973).

Key words:  $\text{Al}_2\text{O}_3$ ; Berg-Barrett; single crystal; skew reflection; vapor growth; x-ray diffraction microscopy.

The most commonly used geometry for the Berg-Barrett x-ray microscopy uses the zero-layer reflections as described by Newkirk. It can be shown that non-zero-layer reflections, skew-plane reflections, can be used equally well to obtain x-ray micrographs. The analysis of the stereographic representation of the skew-reflection geometry demonstrates the many usable reflections and gives the conditions for minimum image distortion. In these x-ray micrographs the contributions to diffraction contrast from shadowing and sub-boundaries can be identified. An estimate of the height of steps occurring on the crystal surface can also be made.

- 13930.** Rowe, J. M., Livingston, R. C., Rush, J. J., **Neutron quasielastic scattering study of  $\text{SH}^-$  reorientation in rubidium hydrosulfide in the intermediate temperature trigonal phase**, *J. Chem. Phys.* **59**, No. 12, 6652-6655 (Dec. 15, 1973).

Key words: neutron scattering; orientational disorder; phase transition; reorientation; residence time; rubidium hydrosulfide; vibration amplitude.

The reorientation of  $(\text{SH})^-$  ions in the trigonal phase of  $\text{RbSH}$  has been investigated by neutron quasielastic scattering at 373 and 393 K. The quasielastic peaks show a distinct two-component (elastic and broadened) structure, the behavior of which is used to establish that the ions are reorienting between two equilibrium sites (presumably by  $180^\circ$  flips along the trigonal axis) with average times between reorientation of  $5.4 \pm 0.4$  psec and  $4.0 \pm 0.4$  psec at 373 and 393 K. Mean square amplitudes of hydrogen vibration are determined from the momentum transfer dependence of the total intensity, and found to be higher than that found in the high temperature fcc phase, even though the rate of reorientation is an order magnitude faster in the cubic phase.

- 13931.** Blunt, R. F., Candela, G. A., Forman, R. A., **Effect of  $\gamma$  irradiation on the magnetic properties of ruby**, *J. Appl. Phys.* **44**, No. 4, 1753-1755 (Apr. 1973).

Key words: aluminum oxide; chromium; color centers; magnetic susceptibility; radiation damage; ruby.

The magnetic susceptibilities of ruby samples ( $\text{Cr}^{3+}$  in  $\alpha\text{-Al}_2\text{O}_3$ ) were measured before and after  $\text{Co}^{60}$   $\gamma$  irradiation. Within the experimental error the magnetic susceptibility was found to be unchanged by the irradiation. The degree of microwave saturation possible for the  $\text{Cr}^{3+}$  spin system, when at the resonance condition for complete saturation, showed a marked decrease after irradiation. Together, these results indicate that the  $\gamma$  irradiation has changed the resonance condition for approximately 10-15 percent of the  $\text{Cr}^{3+}$  in a 0.05 wt%  $\text{Cr}_2\text{O}_3$  sample. A likely inference is that the oxidation state of at least 99 percent of the chromium is unaltered, and that less than 10 ppm Cr has valence differing from three in the irradiated sample. These experiments are in essential agreement with other experiments on ruby.

- 13932.** Barnes, I. L., Garner, E. L., Gramlich, J. W., Machlan, L. A., Moody, J. R., Moore, L. J., Murphy, T. J., Shields, W. R., **Isotopic abundance ratios and concentrations of selected elements in some Apollo 15 and Apollo 16 samples**, (Proc. 4th Lunar Science Conf., March 5-8, 1973, Houston, Tex.), *Geochimica et Cosmochimica Acta, Suppl.* **4**, 2, 1197-1207 (1973).

Key words: chromium; isotopic ratios; lead; model ages; nickel; potassium; rubidium; strontium; thorium; uranium.



The elements Pb, U, Th, Rb, Sr, K, Cr, and Ni have been determined on a series of Apollo 15 and 16 rocks and soils. The elements U, Rb, Cr, and Ni show isotopic abundances identical with those of terrestrial materials in both types of samples but the  $^{39}\text{K}/^{41}\text{K}$  ratio is fractionated by about 1 percent in the soils and the extreme reversed discordancy of the Pb-U-Th ages in the Apollo 16 soils indicated that lead has also been fractionated in these.

The breccia 60335,36 has concordant Pb-U-Th model ages of 4075 MY and the basalt 15495,59 shows one slightly discordant age of around 4480 MY. The Rb-Sr model ages are in good agreement with the Pb-U-Th model ages.

13933. Lenzi, M., McNesby, J. R., Mele, A., Xuan, C. N., Collisional deactivation of  $\text{NH}_2(\tilde{A}^2A_1)$ , *J. Chem. Phys.* **57**, No. 1, 319-323 (July 1, 1972).

Key words: ammonia; fluorescence; Jovian; vacuum ultraviolet.

$\text{NH}_2(\tilde{A}^2A_1)$  was produced by photolysis of ammonia in the vacuum ultraviolet. Deactivation rates of this radical were measured by the quenching of fluorescence in  $\text{NH}_3$ ,  $\text{CH}_4$ ,  $\text{H}_2$ ,  $\text{N}_2$ , He, Ne, Ar, Kr, Xe. An estimate of the lifetime of spontaneous radiative decay of  $0.8 \times 10^{-8}$  sec is suggested. Application of the results to the dynamics of the Jovian atmosphere is reported.

13934. Laughlin, D. E., Cahn, J. W., The crystal structure of the metastable precipitate in copper-based copper-titanium alloys, *Scr. Met.* **8**, 75-78 (1974).

Key words: coherency; copper-titanium;  $\text{D1}_a$ ; electron diffraction;  $\text{L1}_2$ .

Knight and Wilkes recently reported that the metastable ordered phase which forms by precipitation from copper-rich copper-titanium binary alloys is of the type  $\text{L1}_2$ . This note shows that this indexing is incorrect, and that the previously assigned structure of  $\text{D1}_a$  is fully consistent with all experimental findings.

13935. Berger, H. W., Polarography. Constant-current coulometry. Differential thermal analysis, Parts 10.7, 10.8 and 10.9 in *Paint Testing Manual*, Gardner/Sward, 13th Edition, G. G. Sward, Ed., *Amer. Soc. Testing Mater. Spec. Tech. Publ.* **500**, pp. 556-563 (1972).

Key words: coulometric titration; coulometry; differential thermal analysis; diffusion current; dropping mercury electrode; half-wave potential; polarography.

Polarography is an instrumental method of analysis based on the evaluation of current-voltage curves that are obtained during the electro-reduction or oxidation of a chemical compound. The limiting current is diffusion controlled and is a function of concentration. The half-wave potential is the voltage at one-half the diffusion current and is characteristic of the reaction occurring. The dropping mercury electrode, used in polarography, has the particular advantage of being constantly renewed.

Constant current coulometry is a highly accurate analytical technique based on Faraday's Law and involves measuring the number of coulombs (current  $\times$  time) that pass through a chemical cell. Coulometric titrations can be performed by electrogenerating the necessary titrant in situ.

Differential thermal analysis is used for identifying or measuring the physical and chemical changes that occur in materials as they are heated or cooled. The temperature of a test sample is compared to an inert reference and the differential temperature is recorded. Exothermic and endothermic temperature changes are related to chemical reactions or physical transformation.

13936. Rains, T. C., Epstein, M. S., Menis, O., Automatic correction system for light scatter in atomic fluorescence spectrometry, *Anal. Chem.* **46**, No. 2, 207-210 (Feb. 1974).

Key words: atomic fluorescence spectrometry; automatic correction; electrodeless discharge lamp; light scatter; standard reference material.

Light scattering of incident radiation by solvent droplets and unvaporized solute particles in the flame is a major interference in atomic fluorescence spectrometry (AFS). A technique for the automatic correction of light scatter is described which increases the speed and accuracy of analysis. The light from an electrodeless discharge lamp and a 150-W xenon lamp is alternately passed through the flame. The resulting signal from the multiplier phototube is fed to a lock-in amplifier which corrects for the contribution of the light scattering to the fluorescence signal. The principles of the technique and apparatus for making the automatic correction are described. To accomplish this correction, scatter of the incident radiation from the electrodeless discharge and xenon lamps is balanced initially while aspirating a 1 percent lanthanum solution. The method has been applied to the determination of 0.11 and 0.26  $\mu\text{g}$  Cd/gram in SRM's Orchard Leaves and Liver, respectively, without any prior

13937. Newbury, D. E., Yakowitz, H., Yew, N. C., Observation of magnetic domains in nickel using the scanning electron microscope, *Appl. Phys. Lett.* **24**, No. 2, 98 (Jan. 15, 1974).

Key words: bitter patterns; contrast mechanisms; magnetic domains; nickel; scanning electron microscopy; transformer alloy.

Scanning electron microscope (SEM) observation of magnetic domains in a polycrystalline pure nickel sheet was made possible through the use of a 50-kV accelerating potential. The contrast was unobservable in an SEM capable of only a 30-kV accelerating potential.

13938. Costrell, L., Editor, CAMAC—organization of multi-crate system, (AEC Committee on Nuclear Instrument Modules), *AEC Report No. TID-25876*, 42 pages (U.S. Atomic Energy Commission, Washington, D.C., Mar. 1972).

Key words: CAMAC; computer interfacing; control systems; instrumentation; instrumentation standards; nuclear instrumentation; standards.

CAMAC is a design for modular equipment systems used on-line with digital processors and computers and incorporates a comprehensive data transfer highway (Dataway). This extension to the CAMAC specifications defines a Branch Highway and a standard Crate Controller for communication between a system controller or computer and as many as seven crates. The specification has been developed by the ESONE Committee of European Laboratories and has been endorsed by the U.S. AEC Committee on Nuclear Instrument Modules (NIM Committee). Except for pages i-vii and page 30A, this report is identical to Euratom Report EUR 4600e dated October 1971. AEC Report TID-25877 constitutes a supplement to and is to be used in conjunction with this report. The basic CAMAC specifications are defined in AEC Report TID-25875.

13939. Gallagher, A., Lewis, E. L., Determination of the vapor pressure of rubidium by optical absorption, *J. Opt. Soc. Amer.* **63**, No. 7, 864-869 (July 1973).

Key words: rubidium; vapor pressure.

The vapor pressure of rubidium was determined in the neighborhood of 330 K from measurements of optical absorption of the resonance lines. A narrow-line source was used and a full analysis of the line profiles was done. Measurements of resonance-broadening depolarization give another check on the Rb vapor pressure in the 430-K range, assuming that theoretical cross section is correct. The results are very close to the analytic compromise previously suggested by Nesemeyanov.

13940. Wiese, W. L., Regularities in atomic oscillator strengths,



(Proc. VI Yugoslav Symp. and Summer School on the Physics of Ionized Gases, Miljevac by Split, Yugoslavia, July 16-21, 1972), Paper in *Physics of Ionized Gases*, M. V. Kurepa, Ed., pp. 627-649 (Institute of Physics, Beograd, Yugoslavia, 1972).

Key words: atomic oscillator strengths; perturbation theory; regularities; systematic trends.

A review of the recently detected regularities and systematic trends among atomic oscillator strengths is presented. The quantum mechanical background for the existence of these regularities is discussed and, in particular, the relationship between oscillator strengths and nuclear charge as derived from perturbation theory is derived in detail. All regularities are illustrated by some typical graphical or tabular examples.

**13941.** Wiese, W. L., **Experimental studies of the Stark broadening of hydrogen lines**, (Proc. VI Yugoslav Symp. and Summer School on the Physics of Ionized Gases, Miljevac by Split, Yugoslavia, July 16-21, 1972), Paper in *Physics of Ionized Gases*, M. V. Kurepa, Ed., pp. 559-596 (Institute of Physics, Beograd, Yugoslavia, 1972).

Key words: atomic line shapes; critical review; hydrogen lines; plasma sources; Stark broadening.

Recent experimental investigations on the Stark broadening of hydrogen lines by high density plasma sources are critically viewed. The principal requirements for accurate Stark broadening experiments are discussed, and plasma sources, line profile measurements, and diagnostic techniques are reviewed in detail. The most recent experimental results are presented, compared with theory, and their significance for future theoretical work on Stark broadening is pointed out.

**13942.** Howell, B. F., Margolis, S., Schaffer, R., **Residual fluorescence as an index of purity of reduced nicotinamide adenine dinucleotide**, *Clin. Chem.* **19**, No. 11, 1280-1284 (1973).

Key words: alcohol dehydrogenase; fluorescence studies; nicotinamide adenine dinucleotide; optical rotation.

Determination of fluorescence remaining after reduced nicotinamide adenine dinucleotide (NADH) has reacted with excess acetaldehyde in the presence of alcohol dehydrogenase (EC 1.1.1.1) is useful as a criterion of NADH purity when used in conjunction with other methods for determining purity such as the rate of reaction, the ratio of ultraviolet absorbances at 260 nm and 340 nm, the color, and the chromatographic homogeneity of the preparation. Measurement of residual fluorescence monitors the enzymatically inactive material which absorbs at 340 nm. The specific optical rotations of NADH at several wavelengths are also reported.

**13943.** Raveché, H. J., Mountain, R. D., **Structure studies in liquid  $^4\text{He}$** , *Phys. Rev. A* **9**, No. 1, 435-447 (Jan. 1974).

Key words: condensate fraction; ground state wave function; neutron diffraction; pair correlation function; triplet correlation function;  $^4\text{He}$ .

We investigate, using neutron-diffraction data, several properties of the local atomic structure in liquid  $^4\text{He}$ , both above and below the superfluid transition. Distinguishing features of the pair-correlation function are summarized and the diffraction data are employed to investigate a proposed form for the condensate fraction as a function of temperature. The pair-correlation function is used to examine an inequality that gives an upper bound that is close to the observed values, and also to examine the use of approximate integral equations for the ground-state wave function. Triplet correlations and closure approximations are studied from the isothermal density derivative of the pair-correlation function. The results suggest that, analogous to the pair-correlation function, the triple-correlation function shows a tem-

perature dependence that is not observed in simple classical fluids.

**13944.** Kuriyama, M., Early, J. G., Burdette, H. E., **Fluid flow effects on crystalline perfection**, (Proc. 12th Aerospace Sciences Meeting, Washington, D.C., Jan. 30-Feb. 1, 1974), *AIAA Paper No. 74-204*, pp. 1-10 (American Institute of Aeronautics and Astronautics, New York, N.Y., 1974).

Key words: copper single crystals; crystal perfection; dislocations; fluid flow; thermal convection; x-ray topography.

In the absence of gravity, thermal convection, i.e., convection induced by gravity acting on density differences in the melt, would be expected to be negligible. Fluid flow in the melt, including thermal convection, probably affects the perfection of crystals grown from the melt. At present, the relationship between crystal growth conditions, in particular, fluid flow conditions, and the degree of crystal perfection has not been well established for metals. It is, therefore, highly desirable to document the perfection of crystals grown from the melt in terms of directly controllable process parameters, before one even begins to analyse the fluid flow conditions in the melt in terms of thermodynamical variables. In this paper, optimum solidification parameters for the production of highly perfect copper crystals by Czochralski growth are sought along with documentation of crystal imperfections under various growth conditions. A vital part of research of this type is the assessment of crystal perfection. X-ray techniques which do not in their application produce defects and which allow the characterization of imperfections in single crystals are chosen to assess crystal perfection. The properties of crystals grown from the melt are anticipated to vary over a large range, since the growth conditions, especially the fluid flow conditions, are deliberately changed. The x-ray techniques employed ranged from ordinary Laue photography through Borrmann topography to double-crystal scanning diffractometry, thus allowing crystals with a wide variation in perfection to be studied. As a set of controllable solidification parameters, the rotation of the seed and of the melt and the diameter of the bottle-neck are chosen. X-ray diffraction topographs are analysed along with the data obtained from rocking curve measurements. Tables of growth conditions and quantitative data of rocking curve widths are presented.

**13945.** Chang, S-S., **Thermal relaxation and glass transition in polyethylene**, *J. Polym. Sci.*, No. 43, 43-54 (1973).

Key words: annealed; crystallinity; glass transition; polyethylene; relaxation; temperature drifts.

Thermal relaxations in the glass transition region can be observed as spontaneous temperature drifts of the sample under adiabatic conditions. Upon the heating of a quenched glass, positive drifts are observed reaching a peak at some temperature just below its  $T_g$ . An annealed glass produces a peak in the negative drift at temperatures just above its  $T_g$ . Heat capacity measurements have been made on three linear polyethylene samples having 71 to 96 percent crystallinity and on one branched polyethylene sample, in an adiabatic calorimeter from 2 to 360 K. In all four samples, temperature drifts were detected with peaks occurring around 235-240 K. The temperature of the peaks is not significantly affected by the degree of crystallinity. However, the magnitude of the peaks decreases as the crystallinity is increased.

**13946.** Mielenz, K. D., **Eureka!**, *Appl. Opt.* **13**, No. 2, A14 and A16 (Feb. 1974).

Key words: Archimedes; Buffon; burning mirrors; feasibility; history of optics; Second Punic War; solar energy.

In view of the recently renewed controversy whether Archimedes could have used mirrors to defer the attacking Roman fleet during the siege of Syracuse in the Second Punic



War, it is pointed out that the feasibility of this has been demonstrated by Buffon in 1747. Additional facts are presented which also suggest that the use of burning mirrors could have presented a serious threat to the blockading Romans.

- 13947.** Frommer, M. A., Shporer, M., Messalem, R. M., **Water binding and irreversible dehydration processes in cellulose acetate membranes**, *J. Appl. Polym. Sci.* **17**, 2263-2276 (1973).

**Key words:** adsorption of water; cellulose acetate; dehydration; free induction decay; freezing of water; irreversible processes; membranes; NMR; porous membranes.

The relative amounts of freezing and nonfreezing water in various water-wet cellulose acetate (CA) membranes were determined by NMR techniques, from the initial heights of the water component in the free induction decay (NMR intensity). The results suggest that (1) a significant fraction of the water in various wet CA membranes does not freeze, probably because of strong interaction with the polymer; (2) the relaxation times  $T_2$  of the nonfreezing water are of the order of milliseconds indicating that they are still highly mobile compared with ice; (3) all the water contained in dense CA films or in membranes equilibrated at relative humidity of 0.93 does not freeze upon cooling the membranes from room temperature to  $-60^\circ\text{C}$ ; (4) the amounts of nonfreezing bound water in membranes is higher than the total amount of water absorbed from liquid water by a dense film of the same polymer. However, the amounts of nonfreezing water in various CA membranes as calculated from the "relative NMR intensities" is substantially lower than those calculated from DSC melting endotherms by assuming the heat of fusion of water in membranes to be identical to that of pure water. Various possible reasons for this discrepancy are discussed. Measurements on the first desorption-adsorption cycle of wet CA membranes have also been performed. They suggest that during the first dehydration process, irreversible changes are induced in the structure of the membrane which result in a significantly lower accessibility of the polymer to interact with water. The extent of these irreversible changes in membrane structure is dependent on the details of the dehydration process being more pronounced at higher temperatures.

- 13948.** Fanconi, B., **Low-frequency vibrational spectra of some homopolypeptides in the solid state**, *Biopolymers* **12**, 2759-2776 (1973).

**Key words:** far infrared spectroscopy; interchain hydrogen bonding; low frequency vibrations; polypeptides; Raman spectroscopy.

Low-frequency Raman and far-infrared spectra of polyglycine, poly-L-alanine, and poly-L-valine have been measured. The Raman spectra exhibit an intense band near  $100\text{ cm}^{-1}$  for these homopolypeptides. Lattice calculations of the polyglycines are used to assign the intense Raman band to a rotatory lattice mode. For homopolypeptides in the  $\beta$  conformation, an infrared band is observed whose frequency varies inversely with the square root of the mass of the peptide repeating unit. This infrared band is assigned to the hydrogen bond stretching lattice vibration.

- 13949.** Field, B. F., Finnegan, T. F., Toots, J., **Volt maintenance at NBS via  $2e/h$ : A new definition of the NBS volt**, *Metrologia* **9**, No. 4, 155-166 (1973).

**Key words:** Josephson effect; standard cell; tunnel junction; voltage comparator; voltage standard.

This paper describes in detail the procedures, methods and measurements used to establish a new definition of the U.S. legal volt via the ac Josephson effect. This new definition has been made possible by the use of thin film tunnel junctions (capable of producing 10 mV outputs) and high accuracy voltage comparators. The Josephson junction is used as a precise frequency-to-voltage converter with a conversion factor equal to  $2e/h$ . A se-

ries of measurements of  $2e/h$  have been carried out at NBS referenced to the as-maintained unit of emf based on a large group of standard cells. Measurements made at regular intervals over a one year period (1971 to 1972) indicate that the mean emf of this group of standard cells has decreased about 4 parts in  $10^7$ . Primarily to remove the effects of this drift, on July 1, 1972 a new as-maintained unit was defined by choosing a value of  $2e/h$  consistent with the existing unit of emf. The adopted value of  $2e/h$  is  $483593.420\text{ GHz/V}_{\text{NBS}}$ . The precision (one standard deviation) with which the new unit of emf can be maintained with the present techniques and apparatus is about 2 parts in  $10^8$ . The accuracy of the present system is estimated to be 4 parts in  $10^8$ . Comparisons of  $2e/h$  systems at different national laboratories have been limited by uncertainties associated with the physical transfer of standard cells. In order to determine the relative agreement of the various  $2e/h$  systems with precision better than 1 or 2 parts in  $10^7$ , it appears desirable to compare  $2e/h$  systems directly by transporting one of them.

- 13950.** Goldman, A. J., **Approximate localization theorems for optimal facility placement**, *Transp. Sci.* **6**, No. 2, 195-201 (May 1972).

**Key words:** facility location; optimal location.

The problem is that of locating a flow-receiving facility in a region, so as to minimize the weighted sum of distances between sources and facility. It is shown here that if a subregion S both generates "sufficiently much" of the region's total flow, and admits entry via specified "gate" points without "too much" circuitry, then (a) S contains at least one "near-optimal" location for the facility, and (b) no strictly optimal location can lie "too far" from S.

- 13951.** Lee, P. H., Broida, H. P., Braun, W., Herron, J. T., **Direct observation of vibrationally excited hydrogen produced by collisional energy transfer from electronically excited sodium, rubidium, caesium, and mercury**, *J. Photochem.* **2**, 165-172 (1973/74).

**Key words:** absorption spectra; apparatus and method; energy transfer; gases; kinetics of reaction; photochemistry; vacuum u.v.

Hydrogen has been vibrationally excited by direct energy transfer from electronically excited sodium, rubidium and caesium, and mercury. The vibrational excitation of the  $\text{B}^1\Sigma_u^+ \leftarrow \text{X}^1\Sigma_g^+$  transitions in hydrogen was detected by absorption of the vacuum u.v. radiation from a low pressure molecular hydrogen lamp.

- 13952.** McAlister, A. J., Cuthill, J. R., Dobbyn, R. C., Williams, M. L., **Soft x-ray study of the d-bands in  $\text{AuAl}_2$** , (Proc. Int. Conf. on Band Structure Spectroscopy of Metals and Alloys, Strathclyde, Glasgow, Scotland, Sept. 26-30, 1971), Paper in *Band Structure Spectroscopy of Metals and Alloys*, D. J. Fabian and L. H. Watson, Eds., pp. 191-203 (Academic Press, London, England, 1973).

**Key words:** Au;  $\text{AuAl}_2$ ; d-bands; emission spectrum;  $\text{N}_{6,7}$ ; soft x-ray.

The  $\text{N}_{6,7}$  soft x-ray emission spectrum (5d to 4f transition) of Au in  $\text{AuAl}_2$  has been measured. This work, together with the x-ray photoemission results of Chan and Shirley, shows the d-bands to be distributed over a range of approximately 4 eV, with maxima at 5.0 and 7.1 eV below the Fermi level. These results raise some questions about the interpretation of the Al L emission spectrum from the compound, which appeared to offer strong confirmation of nonrelativistic band calculations of the electronic structure of  $\text{AuAl}_2$ , and again raise the possibility of d-band participation in the strong coloring of the compound, an effect which the Al emission spectrum and nonrelativistic band calculations appeared to exclude.



**13953.** Piermarini, G. J., Block, S., Barnett, J. D., **Hydrostatic limits in liquids and solids to 100 kbar**, *J. Appl. Phys.* **44**, No. 12, 5377-5382 (Dec. 1973).

Key words: diamond-anvil pressure cell; glass transition pressures; hydrostaticity; pressure gradients; pressure measurements; ruby fluorescence.

The hydrostatic properties of the materials methanol, isopropyl alcohol, water, sodium chloride, silver chloride, and the binary mixtures pentane-isopentane and methanol-ethanol have been determined in the diamond-anvil pressure cell up to 180 kbar by line-broadening and line-shift measurements of the sharp  $R_1$  ruby fluorescence line. A liquid mixture 4:1 by volume of methanol:ethanol remains hydrostatic to almost 100 kbar at room temperature. This mixture exceeds the hydrostatic limit of the previous generally accepted fluid, 1:1 pentane:isopentane which has a hydrostatic limit of about 70 kbar. Silver chloride and water (ice VII) are better than sodium chloride as pressure-transmitting media, but do not even qualitatively approach hydrostatic conditions much above 70 kbar. The stress sensitivity level of the ruby limits the extent to which slight deviations from hydrostatic conditions can be determined in solid systems and suggests the qualitative nature of the method in characterization of quasihydrostatic states. The equilibrium freezing pressure of methanol at 24 °C was redetermined to be  $35.8 \pm 0.8$  kbar.

**13954.** Arp, V. D., Clark, A. F., Flynn, T. M., **Superconducting levitation of high speed vehicles**, *Transp. Eng. J.* **99**, No. TE4, 873-885 (Nov. 1973).

Key words: fatigue life; magnetic properties; materials; refrigeration; superconducting magnets; suspension; transportation; urban transportation.

The current status (December 1972) of worldwide research on high speed ground transportation techniques is reviewed. Particular attention is given to studies of magnetic levitation using superconducting magnets, including comparison with alternative magnetic techniques and with air suspension systems. Superconducting levitation appears to be a strong contender in the U.S. Department of Transportation hopes to select in the late 1970's the best of the possible levitation techniques for subsequent advanced development. Cryogenic engineering research needed in support of major development of a superconducting levitated system is identified.

**13955.** Mandel, J., Lashof, T. W., **Interpretation and generalization of Youden's two-sample diagram**, *J. Qual. Technol.* **6**, No. 1, 22-36 (Jan. 1974).

Key words: collaborative reference programs; interlaboratory tests; test method evaluation; Youden diagram.

Youden's two sample diagram is a useful method for certain types of interlaboratory comparisons of test results. Generally, points in the plot fall within an elongated ellipse, the major axis of which makes a 45° angle, approximately, with the x, y axes. Occasionally it happens that the axes are not the bisectors of the coordinate axes. This paper (1) examines more closely the assumptions underlying the Youden diagram and presents a more general method of interpreting it and (2) generalizes the diagram to situations where the two samples do not have the same level and/or the axes of the ellipse definitely do not bisect the coordinate axes.

**13956.** Kurylo, M. J., **Kinetics of the reactions  $\text{OH}(v=0) + \text{NH}_3 \rightarrow \text{H}_2\text{O} + \text{NH}_2$  and  $\text{OH}(v=0) + \text{O}_3 \rightarrow \text{HO}_2 + \text{O}_2$  at 298 K**, *Chem. Phys. Lett.* **23**, No. 4, 467-471 (Dec. 15, 1973).

Key words: ammonia; kinetics; OH radical; ozone; stratosphere.

The rate constants for the reactions  $\text{OH}(\text{X}^2\Pi, v=0) + \text{NH}_3 \xrightarrow{k_1} \text{H}_2\text{O} + \text{NH}_2$  and  $\text{OH}(\text{X}^2\Pi, v=0) + \text{O}_3 \xrightarrow{k_2} \text{HO}_2 + \text{O}_2$  were mea-

sured at 298 K by the flash photolysis resonance fluorescence technique. The values of the rate constants thus obtained are  $k_1 = (4.1 \pm 0.6) \times 10^{-14}$  and  $k_2 = (6.5 \pm 1.0) \times 10^{-14}$  in units of  $\text{cm}^3 \text{molecule}^{-1} \text{sec}^{-1}$ . The results are discussed in terms of understanding the dynamics of the perturbed stratosphere.

**13957.** Straty, G. C., Goodwin, R. D., **Dielectric constant and polarizability of saturated and compressed fluid methane**, *Cryogenics* **13**, No. 12, 712-715 (Dec. 1973).

Key words: dielectric constant; methane; polarizability.

Accurate measurements of the dielectric constant of methane have been made on the saturated liquid from near the triple point to 188 K and on the compressed fluid along selected isotherms from 100 K to 300 K and at pressures to 345 bar. The data are combined with accurate densities to obtain the molar polarizability and its dependence on density and temperature. The density range examined extends to nearly three times the critical density. The molar polarizability is found to increase initially with density and then decrease in qualitative agreement with theoretical predictions and the behaviour of other fluids.

**13958.** Goldman, A. J., **Minimax location of a facility in a network**, *Transp. Sci.* **6**, No. 4, 407-418 (Nov. 1972).

Key words: facility location; network theory; optimal location.

The problem is that of locating a facility in a network  $N$  so as to minimize the largest of its distances from the vertices of  $N$ . A method is given that either solves the problem, or else reduces it to an analogous problem for a single "cyclic component" of  $N$ . When  $N$  is acyclic (a tree), a very efficient solution algorithm results. Partial analogs of these results are given for a "weighted-distance" extension of the problem.

**13959.** Perlstein, J. H., Ferraris, J. P., Walatka, V. V., Jr., Cowan, D. O., Candela, G. A., **Electron transport and magnetic properties of new highly conducting TCNQ complexes**, (Proc. 18th AIP Conf. on Magnetism and Magnetic Materials, Denver, Colo., Nov. 28-Dec. 1, 1972), Paper in *Magnetism and Magnetic Materials*, C. D. Graham, Jr., and J. J. Rhyne, Eds., No. 10, 1494-1498 (American Institute of Physics, New York, N.Y., 1973).

Key words: electron transport; magnetic properties; metallic; TCNQ complexes.

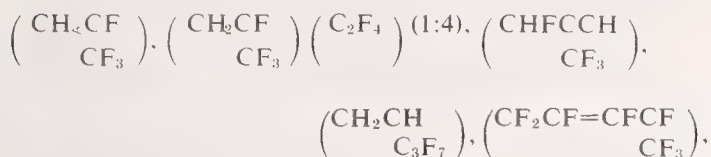
Single crystals of the 1:1 complexes tetrathiafulvalinium tetracyanoquinodimethane (TTF-TCNQ) and tetrathianaphthacinium tetracyanoquinodimethane (TTN-TCNQ) have been synthesized and the electron transport properties and magnetic susceptibility have been measured from 2 K to room temperature. For TTN-TCNQ,  $\sigma$  at room temperature is  $1\Omega^{-1} \text{cm}^{-1}$ . For TTF-TCNQ,  $\sigma$  at room temperature along the long axis ( $\sigma_{\parallel}$ ) is in the range  $192\text{--}652\Omega^{-1} \text{cm}^{-1}$  depending on sample whereas perpendicular to the long axis  $\sigma_{\perp}$  is  $1\Omega^{-1} \text{cm}^{-1}$ . The conductivity remains metallic down to 66 K in both directions whereupon a continuous metal to insulator transition occurs. The activation energy in the insulating state is 0.0062 eV. The transition is associated with a small hysteresis between the heating and cooling curves suggesting a possible structural change. In the metallic region,  $\rho_{\parallel}$  follows a  $T^2$  dependence whereas  $\rho_{\perp}$  follows a  $T^{+1}$  behavior. The magnetic susceptibility is diamagnetic below 20 K becoming increasingly more paramagnetic with increasing  $T$  even in the metallic region. It is suggested that spin disorder scattering may account for the anomalous temperature dependence of  $\rho_{\parallel}$ .

**13960.** Brown, D. W., Florin, R. E., Wall, L. A., **The effect of dilute fluorine on certain fluoropolymers**, *Appl. Polym. Symp.* No. 22, 169-180 (1973).

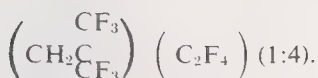
Key words: crosslinking; fluorine; fluoropolymers.



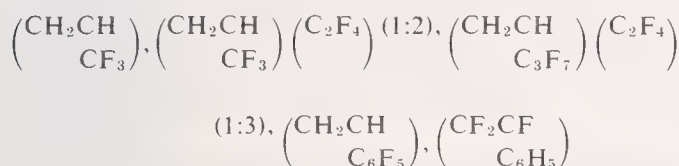
Various fluoropolymers were exposed to 5 percent fluorine in helium at 25 °C and one atmosphere. About 10-100 percent as many fluorine molecules were charged as monomer units in each polymer. Certain polymers degraded as shown by decreases in their intrinsic viscosities. Degrading polymers had the structures



and



The intrinsic viscosity of polyperfluoropropene was not changed. Other polymers cross-linked, as shown by formation of gel. These had the structures



and



In homopolymers the greater the hydrogen content the more likely the polymer was to crosslink, suggesting that crosslinking proceeds via abstraction of hydrogen atoms. However, an increased content of tetrafluoroethylene in copolymers also was associated with greater crosslinking or reduced degradation. Viton and a copolymer of 3,3,3-trifluoropropene gave highly crosslinked materials. The vulkanizates of Viton are quite resistive to stress relaxation at 250 °C in air. Those of the trifluoropropene copolymer are very unstable.

**13961.** Goldberg, R. N., Armstrong, G. T., **Microcalorimetry: A tool for biochemical analysis**, *Med. Instrum.* 8, No. 1, 30-36 (Jan.-Feb. 1974).

Key words: analytical chemistry; bacterial identification; biochemistry; cellular processes; clinical chemistry; enzyme activity; immunochemistry; medical instrumentation; microcalorimetry; thermochemistry.

In order for the application of heat measurements to analysis and clinical chemistry to be feasible, three requirements must be met: (1) specificity of reaction, (2) knowledge of the thermochemistry involved, and (3) adequate instrumentation. Instrumentation requirements are met by devices known as heat conduction microcalorimeters. Some of the principles underlying these instruments are reviewed. The current status of microcalorimetry regarding requirements of sensitivity, sample volume, accuracy, reproducibility, and speed is considered. A brief review of analytical applications that have utilized microcalorimetry is given. These applications include assays for enzymes and substrates, bacterial identifications, and investigation of cellular processes. The advantages and disadvantages of the method as well as possibilities for future development are considered.

**13962.** Kelleher, D. E., Wiese, W. L., **Observation of ion motion in hydrogen Stark profiles**, *Phys. Rev. Lett.* 31, No. 24, 1431-1434 (Dec. 10, 1973).

Key words: Balmer; broadening; dynamic; ion; plasma; Stark.

We have measured the central part of the Balmer  $H_\beta$  or  $D_\beta$  line in similar stabilized arc plasmas, but of different chemical compositions. We have found an ion-motion effect which appears to scale with the inverse square root of the reduced mass of the radiator-perturber system and which, for  $H_\beta$  at least, essentially removes one of the largest remaining discrepancies between experiment and Stark-broadening theory.

**13963.** Bennett, H. S., **Two-electron  $U$  centers in ionic crystals: Point-ion models**, *Phys. Rev. B* 6, No. 10, 3936-3940 (Nov. 15, 1972).

Key words:  $\text{BaF}_2$ ;  $\text{CaF}_2$ ;  $\text{CdF}_2$ ; ionic polarization; KCl; Mollwo-Ivey relations; NaCl; point-ion potential;  $\text{SrF}_2$ ;  $U$  centers.

The Hartree-Fock-Slater (HFS) equations for the two-electron orbitals about a proton located substitutionally at an anion site have been solved numerically in the point-ion lattice potential. The lattice relaxation of the nearest-neighbor ions is included in the model. The five lowest-lying  $U$ -center states for NaCl, KCl,  $\text{CdF}_2$ ,  $\text{CaF}_2$ ,  $\text{SrF}_2$ , and  $\text{BaF}_2$  have been calculated within the framework of the above model. It is found that the low-lying singlet states have the following order for increasing values of the energy:  $^1S(1s, 1s)$ ,  $^1P(1s, 2p)$ , and  $^1S(1s, 2s)$ . The energy levels for the triplet states  $^3S(1s, 2s)$  and  $^3P(1s, 2p)$  lie between the energy levels for the  $^1S(1s, 1s)$  and  $^1P(1s, 2p)$  states. The ordering of the triplet states depends upon the host crystal and the lattice relaxation. In some cases, these triplet states may be degenerate or very nearly so. In addition, the extent to which the peak energies of the  $U$  bands obey Mollwo-Ivey relations is given for the alkali halides and for the alkaline-earth fluorides. The predictions based upon the numerical HFS wave functions are compared with the predictions based upon past variational wave functions and with experiment.

**13964.** Feldman, A., Horowitz, D., Waxler, R. M., **Mechanisms for self-focusing in optical glasses**, *IEEE J. Quantum Electron.* QE-9, No. 11, 1054-1061 (Nov. 1973).

Key words: absorption coefficient; damage threshold; electrostriction; electrostrictive self-focusing; Kerr effect; laser damage; nonlinear index of refraction; self-focusing; thermal self-focusing.

The relative contributions of the Kerr, electrostrictive, and thermal effects to the self-focusing thresholds of borosilicate crown glass, fused silica, and dense flint glass have been estimated from an analysis of damage-threshold data for linearly polarized and circularly polarized radiation. The measurements were made with a Nd:glass laser operating in the TEM<sub>00</sub> mode with a temporal pulsewidth of 25 ns. The Kerr effect appears to be the largest effect. The thermal effect is also significant. The electrostrictive effect is smallest. Reasonable values of the absorption coefficient are calculated from the thermal contribution. The results are in qualitative agreement with the work of others.

**13965.** Hastie, J. W., Hauge, R. H., Margrave, J. L., **Infrared spectra of matrix-isolated species in the gallium-fluorine system**, *J. Fluorine Chem.* 3, 285-291 (1973/74).

Key words: aluminium; fluorides; gallium; infrared spectra; matrix isolation.

The species  $\text{GaF}_3$ ,  $\text{GaF}$ ,  $\text{AlF}_3$ ,  $\text{AlF}$  and  $(\text{AlF})_2$  have been isolated in inert-gas matrices and their infrared absorption spectra obtained over the range 33-4000  $\text{cm}^{-1}$ . The following techniques were used to generate these species; (i) co-deposition of Ga or GaF and molecular  $\text{F}_2$  or F atoms with an excess of inert gas; (ii) Knudsen cell effusion and matrix isolation of the vapors over  $\text{GaF}_3$ ,  $\text{GaF}_3 + \text{Ga}$  and  $\text{GaF}_3 + \text{Al}$ .



**13966.** Currie, L. A., DeVoe, J. R., **The isotope separator as a tool for low-level radioassay and trace activation analysis**, (Proc. Symp. on Nuclear Techniques in Measurement and Control of Environmental Pollution, Salzburg, Austria, Oct. 26-30, 1970), Paper in *Nuclear Techniques in Environmental Pollution*, pp. 183-190 (International Atomic Energy Agency, Vienna, Austria, 1971).

Key words: activation analysis; iodine; mass separation; physical-radiochemical separation.

Determinations of environmental radioactivity and of low-level products of nuclear activation are frequently limited in sensitivity because of isotopic contamination. Sensitivity may be limited by radioisotopes because of interfering radiations and by stable isotopes because of decreased specific activity. To overcome these limitations, electromagnetic isotope separation, which is applicable to most elements, has been investigated as a complement to radiochemical separation and decay scheme resolution. An added advantage of mass separation in environmental studies is the physical separation of a diluting radioisotope—radioisotope dilution being desirable because of the possibility of unknown initial amounts of stable isotopes.

The characteristics of the relatively new class of laboratory isotope separators having moderately large beam currents, 1-5 mA, are particularly suitable, for they include reasonable throughput (~mg/h), yield (~10%) and resolution (~10<sup>3</sup>). Isotope separation was investigated in connection with the neutron activation analysis of trace quantities (~10<sup>9</sup> atoms) of iodine. The mass-separation step was found to be essential because of the production of interfering iodine fission products—even when uranium contamination was as low as 1 ppm. A particularly important result of our investigation was the absence of any detectable blank effect from prior separations. In addition, it has been shown that for certain problems electromagnetic separation, when combined with a high efficiency radiation detector, is far more sensitive and selective than a high resolution detector without mass separation.

**13967.** Richmond, J. C., **A standard for night vision devices for law enforcement**, (Proc. of the Society of Photo-Optical Instrumentation Engineers, San Diego, Calif., Aug. 27-29, 1973), Paper in *Image Intensifiers: Technology, Performance, Requirements and Applications*, A. D. Schnitzler and M. W. Klein, Eds., **42**, 109-115 (1974).

Key words: contrast transfer function; distortion; flare; image intensifiers; law enforcement; light equivalent background; light induced background; night vision; optical gain.

A draft Standard for Passive, Hand-Held Night Vision devices has been developed for the Law Enforcement Standards Laboratory of the National Bureau of Standards. This Standard is now being circulated for comment prior to adoption as a Standard of the National Institute of Law Enforcement and Criminal Justice of the Law Enforcement Assistance Administration of the Department of Justice.

The paper mentions some of the philosophy behind the standard, lists the performance requirements and describes briefly the test procedures for (A) focus adjustment, curvature of field and distortion of the eyepiece lens, (B) optical gain, optical gain stability, light equivalent background, light induced background, luminance of output screen, luminance uniformity, cathode and screen quality, contrast transfer function, distortion and flare of a night vision device complete with objective lens, but with the eyepiece removed, and (C) for resistance to vibration, high and low temperature storage, operation and thermal shock and humidity of night vision devices complete with both objective and eyepiece lenses, and (D) boresight adjustment, click movement

and resistance to mechanical shock of night vision devices intended for use as rifle sights.

**13968.** Brown, D. W., Lowry, R. E., Wall, L. A., **Radiation-induced polymerization at high pressure of *cis*- and *trans*-1,3,3,3-tetrafluoropropene in bulk and with tetrafluoroethylene**, *J. Polym. Sci.* **11**, Part A-1, 1973-1984 (1973).

Key words: copolymerization; high pressure; polymerization; radiation; tetrafluoroethylene; tetrafluoropropene.

The radiation-induced polymerization of *cis*- and *trans*-1,3,3,3-tetrafluoropropene in bulk and with tetrafluoroethylene was studied at pressures between 5000 and 15000 atm and temperatures between 21 and 100 °C. At 10<sup>3</sup> rad/hr the homopolymerization rates range from about 10<sup>-4</sup> to 1 percent/hr. The activation enthalpy and volume are about 8 kcal/mole (33 kJ/mole) and -10 cm<sup>3</sup>/mole, respectively, for both isomers. The *cis* isomer polymerizes about twice as rapidly as the *trans* isomer. The latter freezes in the experimental range of temperature and pressure; the polymerization rate is very low in solid phase. Polymer intrinsic viscosities increase with polymerization pressure and decrease with polymerization temperature; the largest value obtained was 0.23 dl/g. In the copolymerizations all reactivity ratios favor incorporation of tetrafluoroethylene by factors of 6-16. The preference is stronger when the *trans* isomer is used.

**13969.** Olsen, P. T., Driscoll, R. L., **Determination of  $\gamma_p'$  at the National Bureau of Standards**, (Proc. 4th Int. Conf. on Atomic Masses and Fundamental Constants, Teddington, England, Sept. 6-10, 1971), Paper in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds., pp. 471-484 (Plenum Press, London, England, 1972).

Key words: fine structure constant; gyromagnetic ratio of proton; nuclear induction; precision solenoid.

The gyromagnetic ratio of the proton,  $\gamma_p'$  is one of our most important fundamental physical constants. (The prime indicates that the protons are in a spherical sample of pure H<sub>2</sub>O.) Not only is it used for calibration purposes in nuclear magnetic resonance experiments, but it plays a crucial role in determining the fine structure constant from the measurement of  $2e/h$  via the ac Josephson effect. Additionally the continued measurement of  $\gamma_p'$  can be used to monitor as-maintained units of current.

The precision of  $\gamma_p'$  measurements at the National Bureau of Standards (NBS) has improved significantly since the early measurements of the 1950's, from several parts per million (ppm) to the present 0.1 to 0.2 ppm. Current efforts are now being directed towards improving the present 3 to 4 ppm accuracy of the experiment by an order of magnitude. It is the purpose of this paper to briefly report the progress being made in this direction. First, a general discussion of the experiment is given, including (a) use of the method of nuclear induction to determine the precession frequency; (b) a description of a new and improved series of pitch measurements using a laser interferometer; (c) a discussion of the effect of the change in original winding tension on the effective diameter of the windings; and (d) an analysis of the effect of the finite susceptibility of the solenoid and water sample support structure on the calculated magnetic field. All of the known corrections to the field are then summarized, and finally, a brief analysis of the uncertainties in the experiment is given along with a value for  $\gamma_p'$ .

**13970.** Bower, V. E., **Determination of the Faraday by means of the iodine coulometer**, (Proc. 4th Int. Conf. on Atomic Masses and Fundamental Constants, Teddington, England, Sept. 6-10, 1971), Paper in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds., pp. 516-520 (Plenum Press, London, England, 1972).

Key words: coulometry; Faraday; fundamental constants.



This paper describes briefly the work now in progress at NBS on the determination of the Faraday by means of the iodine coulometer. Results obtained to date are compared with a recent determination of the Faraday by means of the silver coulometer and with an adjusted value of the same constant derived from recent determinations of the gyromagnetic ratio of the proton and proton magnetic moment in nuclear magnetons.

**13971.** Galy, J., Roth, R. S., **The crystal structure of  $\text{Nb}_2\text{Zr}_6\text{O}_{17}$** , *J. Solid State Chem.* **7**, 277-285 (1973).

Key words: anion excess fluorite; crystal structure;  $\text{Nb}_2\text{Zr}_6\text{O}_{17}$ ; square anti-prism.

$\text{Nb}_2\text{Zr}_6\text{O}_{17}$  is orthorhombic, space group *Ima2*, with  $a = 40.91$ ,  $b = 4.93$ ,  $c = 5.27$  Å. The asymmetric structural unit contains one octahedron, three sevenfold coordinated ions, and one square antiprism, and its relations to the fluorite and  $\text{ZrO}_2$  structures are discussed. Variations in compositions can be accounted for by increasing or decreasing the number of sevenfold coordinated ions in the structure.

**13972.** Sharman, L. J., Tovey, H., Vickers, A. K., **Current status and national priorities for flammable fabric standards**, *Proc. 6th Annual Meeting of Information Council on Fabric Flammability*, New York, N.Y., Dec. 7, 1972, pp. 265-306 (Information Council on Fabric Flammability, New York, N.Y., May 1, 1973).

Key words: blankets; children's sleepwear; fabric fires; fabric flammability standards; FFACTS; fire injuries; flammable fabrics; flammability standards priorities; garment flammability; garments; sampling plans; upholstered furniture.

The present status (calendar year 1972) of flammability standards issued by the Department of Commerce is described. During 1972, a sampling plan was developed for the Standard for the Flammability of Children's Sleepwear, DOC FF 3-71. The Standard was reissued with this plan included. A Flammability Standard for Mattresses was also issued. Work is in progress on a proposed flammability standard for blankets and flammability test methods for upholstered furniture. The approaches used in development of the standard and the current status of the work are discussed.

The results of a recent analysis of information available to the Fire Technology Division, National Bureau of Standards, on the relative need for specific flammability standards for wearing apparel are discussed. The system used for developing "candidate priorities" for standards is briefly described. A list of high priority garment types is presented, along with examples of compilations of data from the NBS-Flammable Fabrics Accident Case and Testing System (FFACTS) and other sources supporting the placement of the individual garment types on the list.

**13973.** Levin, E. M., Benedict, J. T., Sciarrello, J. P., Monsour, S., **The system  $\text{K}_2\text{SO}_4\text{-Cs}_2\text{SO}_4$** , *J. Amer. Ceram. Soc.* **56**, No. 8, 427-430 (Aug. 1973).

Key words:  $\text{Cs}_2\text{SO}_4$ ; density  $\text{K}_2\text{SO}_4\text{-Cs}_2\text{SO}_4$  solid solutions; equilibrium diagram  $\text{Cs}_2\text{SO}_4\text{-K}_2\text{SO}_4$ ; hexagonal solid solutions;  $\text{K}_2\text{SO}_4$ ; phase diagram  $\text{Cs}_2\text{SO}_4\text{-K}_2\text{SO}_4$ ; polymorphism  $\text{Cs}_2\text{SO}_4\text{-K}_2\text{SO}_4$  solid solutions; solid solutions.

The phase diagram for the system  $\text{K}_2\text{SO}_4\text{-Cs}_2\text{SO}_4$  was determined by using DTA for melting relations and DTA and high-temperature x-ray diffractometry for subsolidus relations. At the solidus the system shows complete solid solubility, with a minimum at 940 °C and 50 mol%  $\text{Cs}_2\text{SO}_4$ . Orthorhombic  $\text{K}_2\text{SO}_4$  and  $\text{Cs}_2\text{SO}_4$ , the stable low-temperature forms, show mutual solid solubility and form a eutectoid at 50 mol%  $\text{Cs}_2\text{SO}_4$  and 430 °C, the lowest temperature of stability of the high-temperature hexagonal solid-solution phase. Isothermal plots of the  $a$  and  $c$  dimensions of this hexagonal phase vs composition show large

positive deviations from linearity for  $c$ . These deviations are interpreted on the basis of the crystal structure of  $\text{KNaSO}_4$  with a similar unit cell.

**13974.** Goldman, D. T., Logan, D. A., **Solid wastes—a technological assessment**, *Chem. Eng. Progr.* **69**, No. 9, 33-35 (Sept. 1973).

Key words: engineering education; solid waste disposal; technology assessment.

A technology assessment is performed on the problem of the disposal of municipal refuse. Various alternative methods are considered including proposed methods for the utilization of solid waste. The identification of those affected by the various alternatives and an evaluation of the impacts these alternatives have on the affected parties are presented. The conclusions of this simple assessment is that sanitary landfills is the most desirable form of presently available disposal methods. For the future, new methods for the utilization of solid waste are required.

**13975.** Mauer, F. A., Hubbard, C. R., **Evaluation of the energy dispersive powder diffraction method for the determination of quartz in dust samples**, (Proc. Roundtable Discussion on Analytical Techniques for Quartz, Cincinnati, Ohio, Dec. 6-7, 1972), Paper in *Analytical Techniques for Quartz*, pp. 17-23 (National Institute for Occupational Safety and Health, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, Jan. 1974).

Key words: analytical methods; industrial hygiene; quartz; silicosis; x-ray diffraction.

An energy dispersive powder diffractometer was assembled and used to determine the amount of quartz on six silver membrane filters, such as those used in sampling airborne dust. The amount of quartz, which varied from 24 to 531  $\mu\text{g}$ , was also determined by weighing. The results obtained indicate that the overall uncertainty in the weight of quartz obtained by the energy dispersive x-ray method is at least 50  $\mu\text{g}$ . The method, therefore, does not meet the National Institute for Occupational Safety and Health requirement for a practical lower limit of detection of 20  $\mu\text{g}$  and an analytical range of 20  $\mu\text{g}$  to 4 mg.

**13976.** Newman, M., **Symmetric completions and products of symmetric matrices**, *Trans. Amer. Math. Soc.* **186**, 191-201 (Dec. 1973).

Key words: fields; principal ideal rings; symmetric completion; symmetric matrices; unimodular matrices.

We show that any vector of  $n$  relatively prime coordinates from a principal ideal ring  $R$  may be completed to a symmetric matrix of  $\text{SL}(n, R)$ , provided that  $n \geq 4$ . The result is also true for  $n = 3$  if  $R$  is the ring of integers  $\mathbb{Z}$ . This implies for example that if  $F$  is a field, any matrix of  $\text{SL}(n, F)$  is the product of a fixed number of symmetric matrices of  $\text{SL}(n, F)$  except when  $n = 2$ ,  $F = \text{GF}(3)$ , which is a genuine exception.

**13977.** Huie, R. E., Herron, J. T., Davis, D. D., **Absolute rate constants for the addition and abstraction reactions of atomic oxygen with 1-butene over the temperature range 190-491 K**, *J. Phys. Chem.* **76**, No. 23, 3311-3313 (1972).

Key words: abstraction reactions; addition reactions; atomic oxygen; reaction kinetics; 1-butene.

Using the technique of flash photolysis-resonance fluorescence, absolute rate constants have been measured for the reaction of ground-state atomic oxygen with 1-butene over the temperature range 190-491 K. With a measured precision of 3-5 percent at each temperature, it was found that the data could not be fit by a single straight line. It was concluded that the curvature in the Arrhenius plot was due to concurrent abstraction and addition reactions, the former process representing approximately 15



percent of the total reaction at 300 K and 39 percent at 500 K. The rate expressions derived were  $k_{\text{addition}} = (3.7 \pm 1.8) \times 10^{-12} \exp(-50 \pm 210 \text{ cal mol}^{-1}/RT) \text{ cm}^3 \text{ molecule}^{-1} \text{ sec}^{-1}$  and  $k_{\text{abstraction}} = (1.6 \pm 0.9) \times 10^{-11} \exp(-1970 \pm 430 \text{ cal mol}^{-1}/RT) \text{ cm}^3 \text{ molecule}^{-1} \text{ sec}^{-1}$ .

**13978.** Dragoo, A. L., *Diffusion*, Chapter IV in *Tantalum: Physico-Chemical Properties of Its Compounds and Alloys, Atomic Energy Review Special Issue*, O. Kubaschewski, Ed., No. 3, pp. 131-133 (International Atomic Energy Agency, Vienna, Austria, 1972).

Key words: chemical interdiffusion; grain-boundary diffusion; intrinsic diffusion; lattice diffusion; self-diffusion; tracer diffusion.

The tracer diffusion coefficient, the self-diffusion coefficient, the intrinsic diffusion coefficient and the interdiffusion coefficient are briefly described. Grain boundary and lattice (volume) diffusion are contrasted. The frequency factors ( $D_0$ ) and activation energies ( $Q$ ) are tabulated for diffusion in the borides, carbides, and oxides of Be, Hf, Mo, Nb, Ta, Th, Ti, and Zr and for diffusion of C, N, and O in these metals. The purity of the solvent media, the preparation and properties of the samples, the method, the type of diffusion coefficient measured and the temperature range are also specified.

**13979.** Dragoo, A. L., *Diffusion*, Chapter IV in *Beryllium: Physico-Chemical Properties of Its Compounds and Alloys, Atomic Energy Review Special Issue*, O. Kubaschewski, Ed., No. 4, pp. 173-175 (International Atomic Energy Agency, Vienna, Austria, 1973).

Key words: chemical interdiffusion; grain-boundary diffusion; intrinsic diffusion; lattice diffusion; self-diffusion; tracer diffusion.

The tracer diffusion coefficient, the self-diffusion coefficient, the intrinsic diffusion coefficient and the interdiffusion coefficient are briefly described. Grain boundary and lattice (volume) diffusion are contrasted. The frequency factors ( $D_0$ ) and activation energies ( $Q$ ) are tabulated for diffusion in the borides, carbides, and oxides of Be, Hf, Mo, Nb, Ta, Th, Ti, and Zr and for diffusion of C, N, and O in these metals. The purity of the solvent media, the preparation and properties of the samples, the method, the type of diffusion coefficient measured and the temperature range are also specified.

**13980.** Armstrong, G. T., *Recent developments in calorimetry and thermochemistry at the National Bureau of Standards*, (Proc. Plenary Lectures of 8th Symp. on Calorimetry and Thermal Analysis, Okayama, Japan, Nov. 1972), Paper in *Calorimetry, Thermometry and Thermal Analysis* 6, 51-60 (Kagaku Gijitsusha, Tokyo, Japan, 1973).

Key words: calorimetry; microcalorimetry of biological processes; standard reference materials for calorimetry; thermochemistry; thermodynamic data.

The thermochemistry work at the National Bureau of Standards provides standard reference data for the National Measurement System both in the form of critical compilations of work done elsewhere and also in the form of new measurements of key substances. A new electrolyte thermodynamic data center has been formed. On-going compilations of the properties of inorganic compounds are being systematized in the form of a catalog of thermochemical quantities. New measurements on organic halogen, nitrogen, and sulfur compounds are extending the range of certified standard reference materials for calorimetry.

A new program on the microcalorimetry of biological processes has shown the applicability of calorimetry to practically important problems of clinical chemistry, and has resulted in improvements in the accuracy of microcalorimetric measurements.

**13981.** Wampler, R. H., *Some recent developments in linear least-squares computations*, (Proc. Computer Science and Statistics 6th Annual Symp. on the Interface, University of California, Berkeley, Calif., Oct. 16-17, 1972), Paper in *Proceedings of the Computer Science and Statistics Sixth Annual Symposium on the Interface*, M. E. Tarter, Ed., 94-110 (Western Periodicals Co., North Hollywood, Calif., Oct. 1972).

Key words: analysis of variance; computer programs; Gram-Schmidt orthogonalization; Householder transformations; ill-conditioned test problems; iterative refinement; least squares computations; linear equations; OMNITAB; regression; rounding errors; statistics.

The results of an evaluation of linear least-squares computer programs (Wampler (174, 175)) are briefly summarized. Subsequent work, including problems encountered, to provide a more accurate least-squares routine for the OMNITAB II program is discussed. In this connection, the comparative results of running a number of ill-conditioned problems on OMNITAB II and two other reliable programs are presented. A bibliography of the recent literature on least-squares analysis has been prepared with special emphasis on the computational aspects of obtaining least-squares solutions.

**13982.** Douglas, W. M., Johannesen, R. B., Ruff, J. K., *Reactions of coordinated ligands. II.  $\mu$ -oxo-bis(difluorophosphineiron tetracarbonyl)*, *Inorg. Chem.* 13, No. 2, 371-374 (1974)

Key words: carbonyl compounds; coordination compounds; fluorophosphine; iron carbonyl; nmr; nuclear magnetic resonance.

Reaction of  $\text{Fe}(\text{CO})_4\text{PF}_2\text{Br}$  with potential sources of the oxide ion (e.g.,  $\text{Ag}_2\text{O}$ ,  $\text{Cu}_2\text{O}$ , etc.) yielded the new complex compound,  $\text{Fe}(\text{CO})_4\text{PF}_2\text{OPF}_2\text{Fe}(\text{CO})_4$ . A more convenient preparation of this material involved the use of  $\text{AgMnO}_4$  instead of the metal oxides. The  $^{31}\text{P}$  and  $^{19}\text{F}$  nmr parameters for the complex were obtained by analysis of the spectra as a  $\text{AA}'\text{XX}'\text{-X}''\text{X}'''$  spin system.

**13983.** Cohen, G. G., Alexandropoulos, N. G., Kuriyama, M., *Relation between x-ray-Raman and soft-x-ray-absorption spectra*, *Phys. Rev. B* 8, No. 12, 5427-5431 (Dec. 15, 1973).

Key words: energy transfer; lithium; momentum transfer; x-ray absorption; x-ray inelastic scattering.

A spectrum of x-ray inelastic scattering of copper  $K\alpha_1 K\alpha_2$  radiation scattered by metallic lithium through  $2\theta = 115^\circ$  was obtained. (These conditions correspond to a momentum transfer  $k = 6.87 \times 10^{10} \text{ m}^{-1}$ .) The spectrum is compared quantitatively to an experimental soft-x-ray-absorption spectrum of lithium. This comparison serves as an experimental verification of the relation between x-ray-Raman spectra and soft-x-ray-absorption spectra. The method renders possible the study of solid-state effects via x-ray Compton-Raman experiments without *ad hoc* assumptions concerning the wave functions of the inner electrons. Also presented is some evidence of the failure of a random-phase approximation and the impulse approximation in the region under investigation.

**13984.** Mount, G. H., Linsky, J. L., Shine, R. A., *One- and multi-component models of the upper photosphere based on molecular spectra. I: The violet system of CN (0,0)*, *Solar Phys.* 32, No. 1, 13-30 (Sept. 1973).

Key words: best-fit model; carbon abundance; molecular spectra; upper photosphere.

Spectroheliograms taken in the CN(0,0) violet band near  $\lambda 3883 \text{ \AA}$  show very small scale network and cell structures with high contrast. The bandhead itself, which is a broad feature due to overlap of several CN lines, allows the diagnostic simplicity of a continuum since motions, magnetic fields, and broadening



mechanisms are unimportant. We have obtained spectroheliograms in the bandhead and center-to-limb photoelectric spectra of CN(0,0) at Kitt Peak National Observatory. From the photoelectric spectra and a detailed analysis of the formation of the CN(0,0) spectrum we derive a best-fit one-component upper photospheric model differing from that of the HSRA and recommend a change in solar carbon abundance from the HSRA value of  $\log A_c = 8.55$  to  $\log A_c = 8.25$ . From the calibrated spectroheliograms we consider a multi-component model to account for the observed fine structure intensity variations.

- 13985.** Hellwig, H., Jarvis, S., Jr., Halford, D., Bell, H. E., **Evaluation and operation of atomic beam tube frequency standards using time domain velocity selection modulation**, *Metrologia* **9**, No. 3, 107-112 (1973).

Key words: atomic beams; cavity phase shift; cesium beam; frequency accuracy; frequency standard; pulsed excitation; second-order Doppler shift; velocity distribution.

Pulsed excitation of atomic and molecular beam devices with separated Ramsey-type interaction regions allows the observation of signals due to very narrow atomic velocity groups. The theoretical background of this method is discussed. Experimental operation of a near mono-velocity cesium beam tube is demonstrated. The velocity distribution of a commercial cesium beam tube is obtained using the pulse method. The normal Ramsey pattern of this beam tube is calculated from the velocity distribution and compared with the measured Ramsey pattern. The pulse method allows the direct determination of the cavity phase shift and of the second-order Doppler correction in beam devices. The pulse method thus shows promise for the evaluation of existing laboratory as well as commercial cesium beam tubes with respect to these effects.

- 13986.** Haber, S., **Numerical evaluation of multiple integrals**, *SIAM Rev.* **12**, No. 4, 481-526 (Oct. 1970).

Key words: best integration formulas; diophantine approximation; Gaussian quadrature; integration; Monte Carlo; multiple integration; multiple quadrature; numerical analysis; numerical integration; optimal formulas; quadrature.

This paper is an expository survey of the main methods that have been developed for numerical evaluation of multiple integrals. Among the approaches discussed are: the Monte Carlo method and its generalizations; number-theoretical methods, based essentially on the ideas of diophantine approximation and equidistribution modulo 1; the functional analysis approach, in which the quadrature error is regarded as a linear functional and one attempts to minimize its norm; and the classical approach of designing formulas to be exact for polynomials of high degree while using as few values of the integrand as possible. Most of the research in this field is quite recent.

- 13987.** Ledbetter, H. M., Naimon, E. R., **Relationship between single-crystal and polycrystal elastic constants**, *J. Appl. Phys.* **45**, No. 1, 66-69 (Jan. 1974).

Key words: Debye temperature; elastic constants; lattice-vibrational properties; polycrystal; single crystal; Voigt-Reuss-Hill.

A new method is given for computing effective polycrystalline elastic constants from single-crystal elastic coefficients. Agreement with observation is good. The method is based on the assumed equivalence of the lattice-vibrational properties of single crystals and polycrystals of the same material; single-crystal and polycrystal Debye temperatures are equated. Present predictions of polycrystal elastic moduli differ significantly from those of most other averaging methods by being lower than the familiar Voigt-Reuss-Hill results.

- 13988.** Hellwig, H., Bell, H. E., **Some experimental results with an**

**atomic hydrogen storage beam frequency standard**, *Metrologia* **8**, 96-98 (1972).

Key words: atomic hydrogen beam; dispersion; frequency stability; frequency standard; hydrogen maser.

A frequency standard is described in which a quartz crystal oscillator is locked to the hydrogen hyperfine transition using the dispersion of this resonance. The hydrogen storage beam apparatus closely resembles a hydrogen maser with a low- $Q$  cavity below oscillation threshold. Cavity pulling can be reduced to a point where environmental temperature fluctuations limit the stability mainly via the second-order Doppler effect. Locking to the dispersion feature of the resonance eliminates the need for frequency modulation in order to find line-center. The stability of the frequency standard was measured against crystal oscillators and cesium beam frequency standards; stabilities of  $4 \times 10^{-13}$  were recorded for sampling times of 30 seconds and of 3 hours.

- 13989.** Allan, D. W., Glaze, D. J., Machlan, H. E., Wainwright, A. E., Hellwig, H., Barnes, J. A., Gray, J. E., **Performance, modeling, and simulation of some cesium beam clocks**, *Proc. 27th Annual Symp. on Frequency Control, Cherry Hill, N.J. June 12-14, 1973*, pp. 334-346 (Electronic Industries Association, Washington, D.C. 1973).

Key words: atomic clock; atomic clock modeling; atomic clock noise; atomic clock performance; atomic time scale accuracy; comparison of atomic time scales; comparison of frequency standards; frequency calibration; frequency drift; simulation of clock performance.

With the availability of a new primary frequency standard, NBS-5 at the National Bureau of Standards, we have been able to evaluate with greater confidence than in the past the performance characteristics of the commercial cesium beam clocks used in the AT(NBS) atomic time scale. Two other techniques have also been employed to evaluate a clock's performance, viz., interclock comparisons and comparisons with other national laboratories.

Utilizing the above performance data we have constructed models for the behavior of cesium beam atomic clocks. Based on these models and appropriate optimization procedures, algorithms have been developed to generate an atomic time scale, AT(NBS), from the ensemble of standards available to us. The model is shown to well fit both individual clocks as well as clock ensembles. This modeling provides a direct opportunity for clock data simulation. Simulation techniques are developed and applied in the testing of some diagnostic tests for frequency and/or time steps. The results are very encouraging as a new effort for even better clock modeling.

Rate calibrations of AT(NBS), UTC(NBS), TAI, and other national time scales are given with reference to NBS-5, and these are compared with other past primary cesium beam frequency standards. TAI was measured as too high in rate by  $12 \pm 5$  parts in  $10^{13}$ .

- 13990.** Glaze, D. J., Hellwig, H., Jarvis, S., Jr., Wainwright, A. E., Allan, D. W., **Recent progress on the NBS primary frequency standard**, *Proc. 27th Annual Symp. on Frequency Control, Philadelphia, Pa., June 12-14, 1973*, pp. 347-356 (Electronic Industries Association, Washington, D.C., 1973).

Key words: cesium beam standard; Doppler effect; frequency accuracy; frequency stability; power shift; primary frequency standard.

The design of NBS-5 is discussed in detail including its relation to previous NBS primary cesium beam frequency standards. The application of pulsed microwave excitation, and the use in the accuracy evaluation of frequency shifts due to known changes in the exciting microwave power are discussed. Signifi-



cant changes in the measured atomic velocity distribution with the beam alignment are reported and compared with measured Ramsey patterns. Stabilities of  $3 \times 10^{-14}$  for one-day averaging are reported and data on accuracy are given. Preliminary results give an evaluated accuracy of  $2 \times 10^{-13}$  with indications that this figure may be improved in the future.

The bias-corrected frequency of NBS-5 agrees to within  $1 \times 10^{-13}$  with the value obtained with NBS-III in 1969 which is preserved in the rate of the NBS Atomic Time Scale.

**13991.** Hellwig, H., Jarvis, S., Jr., Glaze, D. J., Halford, D., Bell, H. E., **Time domain velocity selection modulation as a tool to evaluate cesium beam tubes**, *Proc. 27th Annual Symp. on Frequency Control, Philadelphia, Pa., June 12-14, 1973*, pp. 357-366 (Electronic Industries Association, Washington, D.C., 1973).

**Key words:** atomic beams; cavity phase shift; cesium beam; frequency standard; pulsed excitation; second-order Doppler shift; velocity distribution.

Pulsed excitation of atomic and molecular beam devices with separated Ramsey-type interaction regions allows the observation of signals due to very narrow atomic velocity groups. The theoretical background of this method is discussed. Experimental operation of a near mono-velocity cesium beam tube is demonstrated. The velocity distribution of a commercial cesium beam tube and of the primary laboratory standard NBS-5 are obtained using the pulse method. The normal Ramsey patterns are calculated from the velocity distribution and compared with the measured Ramsey patterns. The pulse method allows the direct determination of the cavity phase shift and of the second-order Doppler correction in beam devices. Velocity distributions obtained via the pulse method allow the use of microwave power shift results for accuracy evaluations. These aspects as well as the effects of modulation and different velocity distributions are discussed in detail. The pulse method thus shows promise for the evaluation of existing laboratory as well as commercial cesium beam tubes with respect to these effects.

**13992.** Simmonds, M. B., **Using the semiconductor junction in quantum interference devices**, *J. Appl. Phys.* **45**, No. 1, 366-368 (Jan. 1974).

**Key words:** Josephson junctions; quantum interference; SQUID.

We have fabricated small-area tunnel junctions of a lead-tellurium-lead structure. These have been used in conjunction with bulk superconductors to make hybrid interference devices. We have successfully operated these devices at bias frequencies of 30 MHz, 300 MHz, and 10 GHz.

**13993.** Lyon, G., **Syntax-directed least-errors analysis for context-free languages: A practical approach**, *Commun. ACM* **17**, No. 1, 3-14 (Jan. 1974).

**Key words:** arbitrary input strings; context-free grammars; dynamic programming; parsing.

A least-errors recognizer is developed informally using the well-known recognizer of Earley, along with elements of Bellman's dynamic programming. The analyzer takes a general class of context-free grammars as drivers, and any finite string as input. Recognition consists of a least-errors count for a corrected version of the input relative to the driver grammar. The algorithm design emphasizes practical aspects which help in programming it.

**13994.** Johnson, C. R., **Gersgorin sets and the field of values**, *J. Math. Anal. Appl.* **45**, No. 2, 416-419 (Feb. 1974).

**Key words:** D-stable matrix; diagonal; doubly stochastic

matrix; field of values; Gersgorin circles; numerical radius; positive definite; spectrum.

Two links are drawn between two well-known inclusion sets for the characteristic roots of a complex matrix: the field of values and the Gersgorin circles. An application is made to the theory of D-stable matrices.

**13995.** Halford, D., **Infrared-microwave frequency synthesis design: Some relevant conceptual noise aspects**, (Proc. Frequency Standards and Metrology Seminar, Quebec, Canada, Aug. 30-Sept. 1, 1971), Paper in *Proceedings of the Frequency Standards and Metrology Seminar*, pp. 431-466 (Quantum Electronics Laboratory, Laval University, Quebec, Canada, 1972).

**Key words:** Allan variance; base units; fast linewidth; frequency multiplication; infrared frequency metrology; Josephson effect; linewidth; methane frequency standard; phase noise; unified standard.

Extremely accurate and precise frequency synthesis into the infrared and visible radiation regions will allow new vistas of metrology. Frequency and time measurements are the basic operations which will be affected, and impact is expected in such diverse areas as length standards and metrology, spectroscopy, timekeeping, communications, and relativistic tests. In addition the set of independent base units of measurement may change, and the speed of light may become a conventional (defined) quantity. The attainment of the desired high accuracy and precision will be easiest and cheapest if there is careful optimization of the synthesis design aspects involving noise. When frequencies in the terahertz region are considered, the linewidth of the signal becomes an important parameter. Due to the low-frequency-divergence of the instability of good signal sources, the concept of the *fast linewidth* becomes of particular importance. Some of the properties and importance of the *fast linewidth* in system design are discussed in this paper.

**13996.** Merris, R., Newman, M., **An explicit isomorphism with applications to inequalities for matrix functions**, *J. Algebra* **25**, No. 3, 468-474 (June 1973).

**Key words:** central idempotents; group algebras; irreducible representations; matrix functions.

Inequalities for matrix functions are derived in a uniform way for an explicit isomorphism.

**13997.** Beehler, R. E., **Recent progress on atomic frequency standards**, (Proc. 1972 Precision Electromagnetic Measurement Conf., Boulder, Colo., June 26-29, 1972), Paper in *CPEM Digest*, pp. 166-167 (IEEE, Inc., New York, N.Y., June 1972).

**Key words:** atomic frequency standards; cesium beam standards; hydrogen masers; rubidium standards.

A brief summary is presented of a paper reviewing progress achieved in the development of atomic frequency standards during recent years. Particular emphasis is placed on cesium, rubidium, and hydrogen maser standards.

**13998.** Allan, D. W., Gray, J. E., Machlan, H. E., **The National Bureau of Standards atomic time scales: Generation, dissemination, stability, and accuracy**, *IEEE Trans. Instrum. Meas.* **IM-21**, No. 4, 388-391 (Nov. 1972).

**Key words:** AT(NBS); clock dispersion; clock ensemble; frequency and time standards; International Atomic Time; Loran-C; model of clock stability; optimum time prediction; precision and accuracy of timing; time coordination, synchronization, and dissemination; UTC(NBS).

The independent atomic time scale at the National Bureau of Standards AT(NBS), is based upon an ensemble of continuously



operating cesium clocks calibrated occasionally by an NBS primary frequency standard. The data of frequency calibrations and interclock comparisons are statistically processed to provide nearly optimum time stability and frequency accuracy. The long-term random fluctuation of AT(NBS) due to nondeterministic perturbations is estimated to be a few parts in  $10^{14}$ , and the present accuracy is inferred to be 1 part in  $10^{12}$ .

A small coordinate rate is added to the rate of AT(NBS) to generate UTC(NBS); this small addition is for the purpose of maintaining synchronization within a few microseconds of other international timing centers. UTC(NBS) is readily operationally available over a large part of the world via WWV, WWVH, WWVB, and telephone; also via some passive time transfer systems, e.g., Loran-C and the TV line-10 system; and also experimentally via satellite and WWVL. The precision and accuracy of these dissemination systems will be discussed.

**13999.** Risley, A. S., **The Josephson junction as applied to the measurement of the frequencies of several laser lines**, (Proc. Frequency Standards and Metrology Seminar, Quebec, Canada, Aug. 30-Sept. 1, 1971), Paper in *Proceedings of the Frequency Standards and Metrology Seminar*, pp. 325-328 (Quantum Electronics Laboratory, Laval University, Quebec, Canada, 1972).

Key words: harmonic generation; Josephson junction; laser frequencies; methane; microwave frequency stability.

The Josephson junction has been applied to the measurement of laser frequencies as high as 3.8 THz by direct multiplication from an x-band source. An attempt is being made to extend this technique to frequencies as high as 10.7 THz.

**14000.** Allan, D. W., **Statistical modeling and filtering for optimum atomic time scale generation**, (Proc. Frequency Standards and Metrology Seminar, Quebec, Canada, Aug. 30-Sept. 1, 1971), Paper in *Proceedings of the Frequency Standards and Metrology Seminar*, pp. 388-410 (Quantum Electronics Laboratory, Laval University, Quebec, Canada, 1972).

Key words: clock stability model; frequency calibration; frequency stability; international time scale; time scale accuracy; time scale stability.

Statistical models for the fractional frequency fluctuations in atomic clocks, clock ensembles, and some of the propagation media are developed. Using these models, near optimum time prediction algorithms are employed to generate time for a clock ensemble or for a set of laboratories' time scales. An example using data from the BIH Circular D bulletin is illustrated and the results compared with IAT.

Accuracy and uniformity problems are considered in light of the CCDS June 1970 recommendations. A model for an evaluable primary frequency standard is developed as well as for a time scale (flywheel frequency standard). It is shown that under certain conditions the accuracy of a time scale can be better than the accuracy of the primary standard for the current calibration, if there is a sufficient number of independent past calibrations. A method of simultaneously achieving accuracy and uniformity is discussed.

**14001.** Naimon, E. R., **Elastic constants of the perovskite  $\text{RbMnF}_3$  using a Born model**, *Phys. Rev. B* 9, No. 2, 737-740 (Jan. 15, 1974).

Key words: Born-Mayer repulsion; Born model; elastic constants; electrostatic interactions; perovskite;  $\text{RbMnF}_3$ .

The elastic constants of  $\text{RbMnF}_3$  were calculated using a Born model, which consists of electrostatic and Born-Mayer repulsive interactions. This model has two adjustable parameters; these were determined from the equilibrium volume and one of the three second-order elastic constants. Calculated third-order

elastic constants agreed reasonably well with experiment. Also calculated were the electrostatic contributions to the first-, second-, and third-order elastic constants of the cubic perovskite structure for several values of ionic charge. Relationships of these constants to those of the NaCl- and CsCl-type structures are given.

**14002.** Costrell, L., **Highways for CAMAC systems—a brief introduction**, *IEEE Trans. Nucl. Sci.* NS-21, No. 1, 870-875 (Feb. 1974).

Key words: CAMAC; computer interfacing; control systems; instrumentation; instrumentation standards; nuclear instrumentation; standards.

The interconnection between CAMAC crates and between the crates and a computer is called the CAMAC highway. The purpose of this paper is to present a brief summary of CAMAC highway configurations to put in perspective the highway papers that follow and to serve as a starting point for the panel discussion on CAMAC highways.

**14003.** Diamond, J. J., Weissler, P. G., **Hearing protectors for use on firing ranges**, *NILECJ-STD-0102.00*, 11 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., Mar. 1973).

Key words: earmuffs; earplugs; firing range noise; gunfire noise; hearing protectors.

This standard establishes performance requirements and methods of test for wearable devices used to protect the auditory system against the gunfire noise on firing ranges. The test method described measures hearing protection by psychoacoustic tests on human subjects, that is, the real-ear protection at threshold of audibility. It is based on ANSI Standard Z24.22-1957.

**14004.** Andrews, J. R., **Inexpensive laser diode pulse generator for optical waveguide studies**, *Rev. Sci. Instrum.* 45, No. 1, 22-24 (Jan. 1974).

Key words: fiber optics; GaAs; impulse; laser; optics; picosecond; pulse; waveguide.

An inexpensive GaAs laser diode pulse generator is presented. This generator has found application in the evaluation of optical pulse dispersion in glass fiber optical waveguide studies. It is capable of producing optical impulses as narrow as 110 psec at a wavelength of  $0.9 \mu$  and a pulse repetition rate of 50 kHz. With a slight modification, it may be used to produce optical pulses of considerably longer duration at reduced repetition rates.

**14005.** Diamond, J. J., Calvano, N. J., **Ballistic resistance of police body armor**, *NILECJ-STD-0101.00*, 10 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., Mar. 1972).

Key words: armor (wearable); ballistic deformation; ballistic penetration; body armor; bullet proof vests.

This standard establishes performance requirements for ballistic penetration, and methods of test for ballistic penetration and deformation of police body armor intended to protect the torso against small arms gunfire. Standards are established for armors intended to provide three levels of protection: Armors protective against .30-06 armor piercing rifle fire, armors protective against .357 magnum revolver fire, and armors protective against .22 long rifle high velocity rifle fire.

**14006.** Roberts, R. W., **Energy research: Scientists seek to ease the pinch**, *The Futurist* VIII, No. 1, 19-22 (Feb. 1974).



Key words: buildings; conservation, energy.

In this period of energy shortage, intensive research and development efforts are required for the development of viable alternatives to traditional energy sources. During the inevitable lag time between energy need and new supply, conservation measures can do much to reduce the energy gap. This is especially true in buildings, where vast amounts of energy are currently wasted. Various NBS programs bearing on the design and operation of more energy efficient buildings are summarized.

- 14007.** Brown, R. L., **Effects of N-atom concentration, pressure, and carrier composition on some first positive band intensities in the yellow nitrogen afterglow**, *J. Chem. Phys.* **52**, No. 9, 4604-4617 (May 1, 1970).

Key words: energy transfer; first positive  $N_2$  bands; Lewis-Rayleigh afterglow; nitrogen afterglow; nitrogen atoms; vibrational relaxation electronic quenching.

Absolute intensities of seven  $N_2$  1st positive bands with  $\nu' = 6-12$  were measured as a function of carrier pressure, carrier composition, and N-atom concentration in the range 4.5-0.06 torr. For an Ar carrier large pressure-dependent shifts in the  $B^3\Pi_g$  vibrational distribution to higher levels were observed below 4 torr; similar but much smaller shifts were also found for  $N_2$  and He carriers. With Ar, reducing the N-atom concentration shifted the vibrational distribution to lower levels. Changes in carrier composition produced large pressure dependent changes in the absolute and relative band intensities. An attempt was made to fit the results to a model involving vibrational relaxation and electronic quenching in  $B^3\Pi$ . While qualitatively successful, this model could not account quantitatively for the observed relative intensity changes over the whole pressure range for which data are available and, in addition, implied physically unreasonable vibrational relaxation rates. It is suggested that the observed changes in the  $B^3\Pi_g$  vibrational distribution below 4 torr may arise from vibrational relaxation in some precursor state.

- 14008.** Scavennec, A., Nahman, N. S., **A simple passively mode-locked CW dye laser**, *IEEE J. Quantum Electron.* **QE-10**, No. 1, 95-96 (Jan. 1974).

Key words: DODCI; dye laser; laser; mode-lock; picosecond; rhodamine 6 G.

The operation of a simple passively mode-locked 5800-Å dye laser is reported. A single active medium, solution of rhodamine 6 G and diethyloxadadicarbocyanine iodide (DODCI) in glycol flowing as an unconfined liquid film, is used for the simultaneous production of gain and nonlinear absorption.

- 14009.** Aminadav, N., Selig, H., Abramowitz, S., **Raman spectrum of  $F_3NO$  gas**, *J. Chem. Phys.* **60**, No. 1, 325-326 (Jan. 1, 1974).

Key words: gas;  $ONF_3$ ; Raman spectroscopy; thermodynamic properties; vibrational analysis.

The Raman spectrum of gaseous  $F_3NO$  has been observed allowing a definite vibrational assignment. The thermal functions have been computed using this assignment and previous microwave and electron diffraction data.

- 14010.** Brennen, W., Brown, R. L., **Measurements on the nitrogen atom and pressure dependences of the visible nitrogen afterglow intensity in a nitrogen carrier using EPR**, *J. Chem. Phys. Letters to Editor* **52**, No. 9, 4910-4911 (May 1, 1970).

Key words: atom recombination; energy transfer; Lewis-Rayleigh afterglow; N-atoms;  $N_2$  first positive bands; nitrogen afterglow.

The relative visible nitrogen afterglow intensity in a  $N_2$  carrier was measured as a function of pressure and N-atom concentration using EPR detection over a range 0.12 to 75 torr. The

specific intensity  $I/[N]^2$  was found to be independent of pressure and  $[N]$ , within the experimental uncertainty.

- 14011.** Kaufman, V., Artru, M.-C., Brillet, W.-U. L., **Revised analysis of the  $2p^53s$ ,  $3p$ ,  $3d$ , and  $4s$  configurations of triply ionized aluminum (Al IV)**, *J. Opt. Soc. Amer.* **64**, No. 2, 197-201 (Feb. 1974).

Key words: aluminum; energy levels; spectra; ultraviolet; wavelengths.

The spectrum of triply ionized aluminum (Al IV) was observed between 700 and 2200 Å. About 60 new lines have been identified as transitions between the  $2p^53s$ ,  $3p$ ,  $3d$ , and  $4s$  configurations. The ground-state combinations have been remeasured (124-161 Å). Energies and designations are given for all levels of these configurations, and several changes and additions to the previous analysis have been made. Results of calculations of these configurations are included to support the level identifications. An isoelectronic comparison is discussed.

- 14012.** McDaniel, C. L., **Phase relations in the systems  $Na_2O$ - $IrO_2$  and  $Na_2O$ - $PtO_2$  in air**, *J. Solid State Chem.* **9**, 139-146 (1974).

Key words: compounds; dissociation;  $Na_2O$ - $IrO_2$  system;  $Na_2O$ - $PtO_2$  system; phase relations.

The equilibrium phase relations for the  $Na_2O$ - $IrO_2$  and  $Na_2O$ - $PtO_2$  systems were determined in air using the quenching technique. The  $Na_2O$ - $IrO_2$  system contains two stable compounds  $Na_2O \cdot IrO_2$  and  $2Na_2O \cdot 3IrO_2$ , which dissociate at 1235 and 1040 °C, respectively. The  $Na_2O$ - $PtO_2$  system contains three compounds:  $Na_2O \cdot PtO_2$ , metastable  $2Na_2O \cdot 3PtO_2$ , and  $Na_xPt_3O_4$  ( $0 \leq x \leq 1$ ). Their dissociation temperatures are 890, 710, and 810 °C, respectively. Indexed x-ray diffraction powder patterns for  $Na_2O \cdot IrO_2$  and  $2Na_2O \cdot 3IrO_2$  are given.

- 14013.** Kayser, B., Lipkin, H. J., Meshkov, S., **Tests of higher symmetries**, *Phys. Rev. D* **8**, No. 11, 4193-4198 (Dec. 1, 1973).

Key words: cross sections; reactions; Regge pole;  $SU(3)$ ; symmetry breaking; trajectory.

Model-independent cross-section relations predicted by unbroken  $SU(3)$  symmetry, and some predicted by  $SU(6)_{W, strong}$ , are compared with experiment. The relations are found to be satisfied, apart from deviations which follow, in every case, the pattern and rough size of symmetry breaking expected from Regge-pole exchange. Interestingly, this Regge symmetry breaking diverges with increasing energy. It is argued that this behavior, though contrary to intuition, is reasonable.

- 14014.** Camarda, H. S.,  **$P$ -wave neutron strength-function measurements and the low-energy optical potential**, *Phys. Rev. C* **9**, No. 1, 28-37 (Jan. 1974).

Key words: function; mass number; neutrons; optical potential;  $R$ -matrix; strength; time-of-flight.

Using the National Bureau of Standards electron linac and underground time-of-flight facility, precise average neutron-transmission measurements have been made in the energy range  $1 \text{ keV} \leq E \leq 600 \text{ keV}$  on the elements As, Br, Nb, Rh, Ag, In, Sb, I, La, Ho, Au, and Th. The samples were "thick" in that the  $s$ -wave self-protection had to be accounted for at low energies. However, the samples were still sufficiently thin that any errors introduced by neglecting  $p$ -wave self-protection were negligible. The average  $R$ -matrix theory was employed in the analysis and the  $l=0$  scattering length  $R'$  and the  $p$ -wave strength function  $S_1$  were extracted from the data. The behavior of  $S_1$  vs mass number  $A$  in the region of the  $3P$  maximum was found to vary smoothly with no evidence of any splitting of the resonance. Using Moldauer's optical potential, which fits the  $l=0$  data well, the behavior of  $S_1$  vs  $A$  was calculated. The predicted behavior



was found to differ significantly from experiment. In particular, experiment indicates  $S_1$  peaks at a lower mass number and that the maximum is stronger than indicated by the calculations. When the constants of the potential were changed in order to reproduce the observed behavior of  $S_1$ , a significant discrepancy with the  $l=0$  data resulted. The results presented here imply an orbital angular momentum dependence of the low-energy optical potential.

- 14015.** Mazur, J., Rubin, R. J., **Average span of self-avoiding walks on the simple cubic lattice**, *J. Chem. Phys. Letters to Editor* **60**, No. 1, 341-342 (Jan. 1, 1974).

Key words: polymer chains; ratio method; self-avoiding walks; span.

In a recent publication, Bellemans concluded that the average span of a self-avoiding walk has a different asymptotic dependence on the number of steps than does the root-mean-square end-to-end distance. In this paper, we reanalyse Bellemans' data and show that there is no basis for his conclusion.

- 14016.** Mazur, J., Guttman, C. M., McCrackin, F. L., **Monte Carlo studies of self-interacting polymer chains with excluded volume. II. Shape of a chain**, *Macromolecules* **6**, No. 6, 872-874 (Nov.-Dec. 1973).

Key words: asymmetry of polymer configurations; excluded volume; principal moments; radius of gyration; self-interacting polymer chains.

The principal moments of the squared radius of gyration of polymer chains with excluded volume were computed for chains on the simple cubic and face-centered cubic lattices. The moments were ordered for each configuration by their magnitude, then averaged over a large number of chain configurations and divided by the squared radius of gyration to yield shape factors of the chain. These shape factors were found to be independent of chain length for long chains. The shape factors showed that the instantaneous shape of a polymer chain is very asymmetrical. With increasing interaction energy between the segments of the chains, the chains became less asymmetrical; at the  $\Theta$  point the shape factors became equal to those of the random coil as previously calculated by Solc and Stockmayer. The relative variations of the principal moments were also calculated. The largest principal moments were found to have the largest relative variations.

- 14017.** Penn, D. R., **An improved Anderson model**, *Phys. Rev. B* **9**, No. 3, 839-843 (Feb. 1, 1974).

Key words: adsorbates on metal surfaces; density of states; impurity wave function; magnetic impurities; phase shift; reformulation of the Anderson model.

The Anderson model has been very successful in the study of (magnetic) impurities in metals and has also proved useful for atoms adsorbed on metal surfaces. The model as originally formulated is phenomenological in that the position and width of the resonant impurity state cannot be calculated within the context of the model even in the absence of correlation effects. Anderson and McMillan and also Kanamori have proposed theories which are more quantitative. We show that the results of both theories follow from very simple assumptions. Moreover, we show that for the case of a free-electron-like metal and a spherical impurity potential both theories will give a correct density of states for the metal plus impurity if the wave function associated with the impurity is chosen properly. This is particularly important for the theory of Kanamori where the use of a non-Hermitian Hamiltonian raises questions about its validity. The best choice for the impurity wave function requires it to be energy dependent, unlike that one which appears in the usual Anderson model. However, it is shown that an energy-independent wave function can be chosen such that the Anderson-McMillan and Kanamori theories will yield a good density of states.

- 14018.** Dehl, R. E., **NMR second moment of rotator-phase polycrystalline  $n\text{-C}_{19}\text{H}_{40}$** , *J. Chem. Phys. Letters to Editor* **60**, No. 1, 339-340 (Jan. 1, 1974).

Key words: molecular rotation; NMR second moment;  $n$ -nonadecane; paraffin; rotator phase; wideline NMR.

The proton NMR second moment of polycrystalline  $n\text{-C}_{19}\text{H}_{40}$  in the rotator phase at 25 °C was measured for several spectra of the as-received ("98.5%") and the solution-recrystallized paraffin (0.060 (mT)<sup>2</sup>) was considerably lower than that of the recrystallized paraffin (0.076 (mT)<sup>2</sup>), indicating the importance of chemical purity in obtaining accurate second moments of paraffins. The results for the recrystallized paraffin were significantly lower than Andrew's theoretical prediction (0.088 (mT)<sup>2</sup>), but significantly higher than the value predicted by Olf and Peterlin (0.064 (mT)<sup>2</sup>). Because of these discrepancies, the theoretical NMR second moment of the "rotator" paraffin was reevaluated, using exact calculations of the most important dipolar contributions and estimates of the smaller terms. The calculated and observed values were thus found to differ by only 4 percent. The NMR second moment is consistent with simple rotation or large-amplitude oscillation of the chains about their long axes.

- 14019.** Kessler, K. G., **Absolute measurements of differential cross sections for electron scattering at intermediate energies (50-500 eV)**, *Comments At. Mol. Phys.* **1**, No. 3, 70-72 (Aug.-Sept. 1969).

Key words: differential cross sections; elastic cross sections; electron scattering.

Technological improvements in the design and construction of electron impact spectrometers now make possible more reliable absolute measurements of elastic and inelastic differential cross sections for the scattering of electrons by atoms and molecules. Cross sections can now be determined with an imprecision of 5 percent or less, depending upon the degree to which systematic errors are brought under control.

- 14020.** McCrackin, F. L., Mazur, J., Guttman, C. M., **Monte Carlo studies of self-interacting polymer chains with excluded volume. I. Squared radii of gyration and mean-square end-to-end distances and their moments**, *Macromolecules* **6**, No. 6, 859-871 (Nov.-Dec. 1973).

Key words: excluded volume; Monte Carlo; polymer solution; radii of gyration; theta point.

Random walks that are not allowed to intersect themselves were generated on the simple cubic and face-centered cubic lattices and used as a model of a linear polymer chain in dilute solution with excluded volume and attractive energies between chain elements. The mean-square end-to-end distances and mean squared radii of gyration and their moments were computed for chain lengths up to 2000 segments and for a wide range of attractive energies. The partition functions of the chains were also computed. The attractive energy required for a given property of the chain to be the same as the given property of a random coil, the  $\theta$  point, was investigated. The required attractive energy depended slightly on the particular property chosen for comparison, so rather than a unique  $\theta$  point, a narrow range of  $\theta$  points was found.

- 14021.** Shumaker, J. B., **A spectroscopic study of equilibrium in nitrogen arcs**, *J. Quant. Spectrosc. Radiat. Transfer* **14**, 19-26 (1974).

Key words: arc plasma; equilibrium; LTE; nitrogen.

Nitrogen arc measurements of the intensity of the 4915 Å — 4935 Å NI doublet and of the 3995 Å NII line show that local thermodynamic equilibrium cannot be assumed in nitrogen arcs at electron densities below  $1 \times 10^{17} \text{ cm}^{-3}$ . Below this point, the



results suggest that gas and electron temperatures differ significantly and that ground states are overpopulated with respect to upper electronically excited states.

- 14022.** Geltman, S., Teague, M. R., **Atomic absorption of ultra intense laser radiation**, *J. Phys. B: At. Mol. Phys. Letter to Editor* 7, No. 1, L22-L27 (1974).

Key words: atoms; free-free absorption; ultra-intense laser radiation.

We derive an expression for the rate of absorption by an atomic system (bound or free) of radiation from an ultra intense laser beam. The absorption characteristics are radically different from those of conventional weak-field absorption theory.

- 14023.** Mozer, B., De Graaf, L. A., Le Neindre, B., **Neutron-diffraction studies in liquid  $^4\text{He}$** , *Phys. Rev. A* 9, No. 1, 448-459 (Jan. 1974).

Key words: condensate fraction; density and temperature; liquid helium; neutron diffraction; pair correlation and three-atom correlation function; structure factor.

Structure factors of liquid helium have been determined from neutron-diffraction measurements of high statistical accuracy. Diffraction measurements were performed out to momentum transfers of  $7 \text{ \AA}^{-1}$  for three different densities of liquid helium at a constant temperature above the helium  $\lambda$  transition and at a nearly constant temperature below the  $\lambda$  transition for the same three densities. Statistically significant differences in the structure factors are observed as the density is varied at constant temperature and for temperatures above and below the  $\lambda$  transition at constant density. The radial pair-correlation functions have been calculated from the liquid-structure factors. The structure factors or the related radial pair-correlation functions can be used to obtain information about three-atom correlations in liquid helium above and below the  $\lambda$  transition from a construction of their isothermal density derivative. The temperature dependence of the constant-density structure factors or their derived pair-correlation functions can also be used to test a current theoretical estimate of the condensate fraction in liquid helium.

- 14024.** Verdier, P. H., **Monte Carlo studies of lattice-model polymer chains. III. Relaxation of Rouse coordinates**, *J. Chem. Phys.* 59, No. 11, 6119-6127 (Dec. 1, 1973).

Key words: excluded volume; lattice-model polymer chains; Monte Carlo; polymer chain dynamics; relaxation times.

The relaxation of the seven lowest Rouse coordinates for simple lattice models of polymer chains of up to 64 beads, with and without excluded volume, is studied by simulation on a digital computer. The similarity between the relaxation of the lattice-model chains without excluded volume and that of a statistical-bead model, noted in previous studies of end-to-end length, is confirmed and examined in greater detail. The effect of excluded volume in slowing down the relaxation of the Rouse coordinates is examined, and a simple picture is suggested which accounts qualitatively for the results obtained. The nonnormal coordinate nature of the Rouse coordinates for chains with excluded volume is demonstrated by their nonexponential autocorrelation functions. However, the results suggest that for each chain length, there is a unique longest internal relaxation time, corresponding to an internal coordinate closely resembling the lowest Rouse coordinate.

- 14025.** Kranbuehl, D. E., Verdier, P. H., Spencer, J. M., **Relaxation of fluctuations in the shape of a random-coil polymer chain**, *J. Chem. Phys. Letter to Editor* 59, No. 7, 3861-3862 (Oct. 1, 1973).

Key words: lattice-model polymer chains; Monte Carlo; polymer chain dynamics; relaxation times.

The relaxation times of deviations from spherical symmetry of random-coil polymer chains in dilute solution have been investigated by dynamical Monte Carlo studies of lattice-model chains without excluded volume. The deviations are found to persist for times of the order of the longest relaxation times of the internal motions of the chains.

- 14026.** Dehl, R. E., **The effect of salts on the nmr spectra of  $\text{D}_2\text{O}$  in collagen fibers**, *Biopolymers* 12, 2329-2334 (1973).

Key words: collagen;  $\text{D}_2\text{O}$  in collagen; deuterium nmr;  $\text{MgCl}_2$  in collagen;  $\text{MgSO}_4$  in collagen; wideline nmr.

The effects of two salts,  $\text{MgCl}_2$  and  $\text{MgSO}_4$ , on the wide-line nmr spectrum of  $\text{D}_2\text{O}$  in oriented, undenatured collagen fibers have been examined at four different  $\text{D}_2\text{O}$  contents.  $\text{MgCl}_2$  was found to decrease the nmr doublet splitting, as compared with equal quantities of pure  $\text{D}_2\text{O}$ , while the major effect of  $\text{MgSO}_4$  was to inhibit the adsorption of  $\text{D}_2\text{O}$  without significantly affecting its nmr spectrum. The results, together with a few observations of KCl and LiCl solutions, indicate that even fairly high concentrations of salt have only small effects on the nmr spectrum of  $\text{D}_2\text{O}$  in fibrous collagen. It is considered unlikely that either "two-state" or "structured-water" models can satisfactorily account for the  $\text{D}_2\text{O}$ -nmr doublet spectrum or the effects of salts on it, over the entire range of observed  $\text{D}_2\text{O}$  content.

- 14027.** Madey, T. E., Yates, J. T., Jr., Erickson, N. E., **ESCA study of fractional monolayer quantities of chemisorbed gases on tungsten**, *Chem. Phys. Lett.* 19, No. 4, 487-492 (Apr. 15, 1973).

Key words: carbon monoxide; ESCA; monolayer; oxygen; photoyields; sensitivity; tungsten.

X-ray photoelectron spectroscopy (ESCA) has been used in a study of CO and  $\text{O}_2$  chemisorbed on a polycrystalline tungsten sample. Working under ultrahigh vacuum conditions, the surface was cleaned and then covered with known monolayer and fractional monolayer quantities of adsorbed CO and  $\text{O}_2$ . The O(1s) and C(1s) spectral features were detected, and the influence of an adsorbed layer on the tungsten spectral features was determined. A chemical shift of 3.4 eV in the O(1s) line from chemisorbed CO is related to the different modes of bonding of CO to tungsten. A model calculation of the photoelectron yields expected from an adsorbed monolayer is in good agreement with the experimental results.

- 14028.** Halford, D., Shoaf, J. H., Risley, A. S., **Spectral density analysis: Frequency domain specification and measurement of signal stability**, *Proc. 27th Annual Symp. on Frequency Control, Cherry Hill, N.J., June 12-14, 1973*, pp. 421-431 (Electronic Industries Association, Washington, D.C. 10006).

Key words: amplitude fluctuations; cross-spectral density; frequency domain; frequency noise; modulation noise; noise specification and measurement; oscillator noise; phase noise; radio frequency power spectral density; script  $\mathcal{L}(f)$ ; script  $\mathcal{M}(f)$ ; script  $\mathcal{N}$ ; sidebands; signal stability; spectral density.

Stability in the frequency domain is commonly specified in terms of spectral densities. The spectral density concept is simple, elegant, and very useful, but care must be exercised in its use. There are several different but closely related spectral densities, which are relevant to the specification and measurement of stability of the frequency, phase, period, amplitude, and power of signals. Concise, tutorial descriptions of useful spectral densities are given in this survey. These include the spectral densities of fluctuations of (a) phase, (b) frequency, (c) fractional frequency, (d) amplitude, (e) time interval, (f) angular frequency, and (g) voltage. Also included are the spectral densities of radio frequency power and its two normalized components, Script  $\mathcal{L}(f)$  and Script  $\mathcal{M}(f)$ , the phase modulation and amplitude modulation por-



tions, respectively. Some of the simple, often-needed relationships among these various spectral densities are given. The use of one-sided spectral densities is recommended. The relationship to two-sided spectral densities is explained. The concepts of cross-spectral densities, spectral densities of time-dependent spectral densities, and smoothed spectral densities are discussed.

- 14029.** Thrower, P. A., Nagle, D. C., Horton, W. S., **The anisotropy of pyrolytic graphite**, *J. Appl. Crystallogr.* **6**, Part 5, 347-351 (Oct. 1973).

Key words: magnetic susceptibility; orientation function; preferred orientation; pyrolytic graphite.

Two proposed expressions,  $I_1(\phi) = \cos^m \phi$  and  $I_2(\phi) = (1 + b^2 \sin^2 \phi)^{-1}$ , for the orientation function,  $I(\phi)$ , of pyrolytic graphites have been shown analytically to give quite different values for the Bacon anisotropy factor (BAF) for oriented materials. BAF values derived from the angle of half-maximum intensity using  $I_1(\phi)$  are within 20 percent of numerically calculated values for the BAF range 10-90, whereas values obtained using  $I_2(\phi)$  are smaller by as much as a factor of twenty. The effect of sample preparation on such measurements has been found to be negligible. Diamagnetic-susceptibility measurements on the graphites investigated validated the calculated BAF values in that the derived single-crystal susceptibilities were in reasonable agreement with known values. BAF values calculated via  $I_2(\phi)$  produced unacceptable paramagnetic values parallel to the basal plane. It is suggested that  $I_1(\phi)$  be used for rapid BAF determinations; although numerical calculation is preferred, the difficulty of measuring  $I(\phi)$  at large  $\phi$ , for highly oriented materials, may make the full numerical procedure impracticable and this approximate procedure the more desirable.

- 14030.** Gebbie, K. B., Steinitz, R., **On spatial variations in the intensity of chromospheric H $\alpha$** , *Astrophys. J.* **188**, No. 2, 399-406 (Mar. 1, 1974).

Key words: features observed in H $\alpha$ ; H $\alpha$  filtergrams; lateral contrasts in intensity; profile variation mechanism.

We investigate the formation of patterns in H $\alpha$  spectroheliograms and filtergrams. Introducing a *source-sink-control diagram*, we conclude that the H $\alpha$  line source function in the quiet solar chromosphere is indirectly controlled by the photospheric radiation fields in the Balmer and Paschen continua. We demonstrate that in producing the observed patterns, horizontal spatial variations in the shape of the absorption profile are extremely effective compared to changes in the source and sink terms. Applying this mechanism, we compute asymptotic values for the contrasts and visibilities in chromospheric H $\alpha$ .

- 14031.** Moos, H. W., Linsky, J. L., Henry, R. C., McClintock, W., **High-spectral-resolution measurements of the H I  $\lambda$  1216 and Mg II  $\lambda$  2800 emissions from arcturus**, *Astrophys. J.* **188**, No. 3, L93-L95 (Mar. 15, 1974).

Key words: late-type stars; OAO spectroscopic observations; stellar chromospheres; stellar ultraviolet observations.

High-spectral-resolution scans of H I  $\lambda$  1216 and Mg II  $\lambda$  2796, 2803 obtained using the ultraviolet spectrometer aboard the *Copernicus* satellite show broad and very asymmetrical emission profiles. The ratio of the line widths to the solar values is consistent with a law similar to the Wilson-Bappu relation for the calcium K reversal. A fit of the interstellar absorption profile indicates that the average H density toward this nearby star is low,  $0.02 - 0.1 \text{ cm}^{-3}$ .

- 14032.** Frommer, M. A., Messalem, R. M., **Mechanism of membrane formation. VI. Convective flows and large void formation during membrane precipitation**, *I&EC Prod. Res. Develop.* **12**, 328-333 (Dec. 1973).

Key words: convection flows; desalination; interfacial turbulence; membranes; membrane structures; polymer precipitation; scanning electron micrographs.

The factors governing the formation of voids and large cavities in a wide variety of membranes made from different polymers cast from different solvents and precipitated in various nonsolvents have been studied. It has been shown that the formation of large voids in membranes can be eliminated by (1) lowering the tendency of the nonsolvent to penetrate into the casting solution or (2) increasing the viscosity of the cast solution or creating a thick gel layer on top of this cast solution. It is suggested that the formation of large finger-like cavities in membranes originates from convective flows formed within the cast (fluid) polymer solution upon its immersion in the bath of nonsolvent for final precipitation. It is also shown that the driving forces leading to the formation of these convective flows are not density gradients.

- 14033.** Johnson, C. R., **A note on matrix solutions to  $A = XY - YX$** , *Proc. Amer. Math. Soc.* **42**, No. 2, 351-353 (Feb. 1974).

Key words: commutator; eigenvalues; positive definite; trace.

It is known that a square matrix  $A$  can be written as a commutator  $XY - YX$  if and only if  $\text{Tr}(A) = 0$ . In this note it is shown further that for a fixed  $A$  the spectrum of one of the factors may be taken to be arbitrary while the spectrum of the other factor is arbitrary as long as the characteristic roots are distinct. The distinctness restriction on one of the factors may not in general be relaxed.

- 14034.** Radziemski, L. J., Jr., Kaufman, V., **Wavelengths, energy levels, and analysis of the second spectrum of chlorine (Cl II)**, *J. Opt. Soc. Amer.* **64**, No. 3, 366-389 (Mar. 1974).

Key words: chlorine; energy levels; spectra; wavelengths.

We have observed the spectrum of singly ionized chlorine (Cl II) with grating spectrographs from 500 to 11 000 Å using a ring discharge and a pulsed rf-discharge source. The accuracy of the observed wavelengths is about 0.002 Å from 500 to 3000 Å and 0.01 Å from 3000 to 11 000 Å. The number of known energy levels has increased from 140 to 270 and the number of classified lines from 600 to over 1100. We have found 25 levels of  $3p^3 \text{ } ^n\text{G}$  ( $n = 5-8$ ) and 59 levels of  $3p^3 \text{ } ^n\text{F}$  ( $n = 4-10$ ), including all 20 levels of  $3p^3 \text{ } (^2D)4f$ . Combinations with the latter levels gave new information on the singlets in the  $3p^3 \text{ } ^3\text{D}$  configuration, which led to the rejection of some levels, the establishment of others, and many changed assignments. *Ab initio* energy-level and spectrum calculations and least-squares energy-level fits showed large interactions between the  $3s \text{ } 3p^5$ ,  $3s^2 \text{ } 3d$ , and  $3s^2 \text{ } 3p^3 \text{ } 4d$  configurations. The ionization limit of  $\text{Cl}^+$  is  $192070 \pm 1 \text{ cm}^{-1}$ .

- 14035.** Oettinger, F. F., Gladhill, R. L., **Thermal response measurements for semiconductor device die attachment evaluation**, *1973 IEDM Tech. Digest*, pp. 47-50 (1973).

Key words: die attachment evaluation; diode die attachment; screen, die attachment; transistor die attachment.

This paper discusses an improved technique, based on transient thermal response measurements, to nondestructively evaluate die attachment in semiconductor devices. The technique was confirmed with studies performed on diodes bonded to TO-5 headers and transistors bonded to both TO-5 and TO-66 headers with voids intentionally incorporated into the die attachment. The advantages of using the transient thermal response technique for screening semiconductor devices for poor die attachment are emphasized.

- 14036.** Wagner, H. L., **The polymer standard reference materials program at the National Bureau of Standards**, *Adv. Chem. Series No. 125*, pp. 17-24 (1973).



Key words: gel permeation chromatograph calibration; limiting viscosity number; molecular weight; molecular weight distribution; polyethylene standard; polystyrene standard; standard reference materials; standard reference polymers.

The National Bureau of Standards now distributes four polymer Standard Reference Materials designed for use in the calibration of instruments employed in polymer characterization. Polystyrene is available in narrow (SRM 705) and broad (SRM 706) distributions and polyethylene in high-density linear (SRM 1475) and low-density branched (SRM 1476) whole polymer. These materials are characterized with respect to many but not necessarily all of the following properties: weight and number-average molecular weight, limiting viscosity number in several solvents, ASTM density, and ASTM melt flow rate. In addition the molecular-weight distribution of the linear polyethylene is given, making it suitable for the calibration of gel-permeation chromatographs at high temperatures.

**14037.** Wachtman, J. B., Jr., **The influence of surface features on the strength of polycrystalline alumina**, (Proc. 1971 Int. Conf. Mechanical Behavior of Materials, Kyoto, Japan, Aug. 13-31, 1971), Chapter in *Mechanical Behavior of Materials* 4, 432-442 (The Society of Materials Science, Kyoto, Japan, 1972).

Key words: fracture surface energy; machining damage; plastic deformation; polycrystalline alumina; strength; surface features; thermal expansion anisotropy.

Fracture surface energy of polycrystalline alumina measured with large cracks ranges from 10 to 46 J/m<sup>2</sup>; the critical surface energy depends on the size of the fracture nucleus. For single crystals, values depend on the plane of the crack with a minimum of 6 J/m<sup>2</sup> for (10 $\bar{1}$ 1). On this basis failure results from surface microcracks only one fourth the average grain diameter. The thermal expansion anisotropy stress acting on this size crack is 1.5 times the value calculated for an internal crack due to surface proximity. Hardness indentations produce cracks at high loads but reduce strength only when a greater critical load, which increases with decreasing grain size, is exceeded. This behavior apparently corresponds to a range of safe machining.

**14038.** Horton, W. S., **A relationship between the magnetic susceptibilities of pyrolytic and single crystal graphites**, *Proc. 11th Biennial Conf. on Carbon, Gatlinburg, Tenn., June 4-8, 1973*, Paper EP-2, pp. 2-3 (1973).

Key words: anisotropy; magnetic susceptibility; pyrolytic graphite; single crystal graphite.

Actual magnetic susceptibility data are compared with the relation  $\chi_{\perp} + 2\chi_{\parallel} = 3\chi_r$  where the first two susceptibilities refer to those perpendicular and parallel to the deposition plane, and  $\chi_r$  is that for a random mixture of perfect crystals. A parabolic rather than linear relation appears to fit better empirically. An intersection of the straight and curved lines appears to be close to the measured values of principal magnetic susceptibilities of good single crystal graphite.

**14039.** Gravatt, C. C., Jr., **Real time measurement of the size distribution of particulate matter by a light scattering method**, *APCAJ*, 23, No. 12, 1035-1038 (Dec. 1973).

Key words: air pollution; light scattering; particulate matter.

The body of information presented in this paper is directed to those individuals concerned with the measurement of the size distribution of particulate matter in air. The light scattering instrument described herein is characterized by the fact that it can accurately size particles almost independently of their index of refraction. The basic concept involves the simultaneous measurement of the intensity of light scattered by a single particle at two small scattering angles. The ratio of the two intensities is

directly related to the size of the particle, and for scattering angles of 5 and 10° the effective range of the instrument is 0.2 to 4  $\mu$ m. The air flows through the optical system at such a rate that approximately 25  $\mu$ s are required to determine the size of each particle, and concentrations as high as 10<sup>4</sup> particles/cc can be measured without dilution and without serious coincidence effects. By employing a multichannel analyzer as the data storage and readout device it is possible to detect changes in particulate size distribution within a few seconds. Calibration of the instrument has been performed using polystyrene latex spheres and materials having a wide range of index of refraction and shape including carbon black, iron oxide and spores.

**14040.** McCall, R. C., Nelson, W. R., Wyckoff, J. M., Pruitt, J. S., **Angular distribution of thick target bremsstrahlung**, *Proc. Second Int. Conf. on Accelerator Dosimetry and Experience, SLAC, Stanford, Calif., Nov. 5-7, 1969*, Conference Report No. 691101, pp. 684-691 (1969).

Key words: angular distribution; depth-dose; photon energy; Ta target; thermoluminescent detectors; 30 and 57.4 MeV electrons.

The angular distributions of dose due to 30 and 57.4 MeV electron beams striking a thick Ta target have been measured using small thermoluminescent detectors. Depth-dose curves measured at 5 and 135° have been used to demonstrate the contribution of secondary electrons in free air, at a plexiglas surface and at 9.25 g/cm<sup>2</sup> inside the plexiglas. Comparisons are made with calculated angular distributions of the photon energy emitted showing fair agreement.

**14041.** Goldberg, S., Ogburn, F., **Plating standards and specifications**, Chapter 7 in *Electroplating Engineering Handbook (3d Edition)*, pp. 258-271 (Van Nostrand Reinhold Co., New York, N.Y., 1972).

Key words: coating thickness; coatings; electrodeposited coatings; electrodeposits; metal coatings; plated coatings; plating specifications; plating standards; specifications.

The electroplated coating specifications of the ISO, the ASTM, and the U.S. Government are discussed in some detail. The requirements of the specifications and the test methods are reviewed and coating thickness requirements are tabulated. A number of the applications for which various types of plated coatings suitable are discussed.

**14042.** Filliben, J. J., **Comments on the paper "Treatment of null responses," by G. L. Meyer and R. L. Johnson**, *Proc. 17th Conf. on the Design of Experiments in Army Research Development and Testing, Washington, D.C., Oct. 27-29, 1971*, ARO-D Report 72-2, pp. 397-402 (Sept. 1972).

Key words: camouflage; design of experiment; null responses; paired comparisons; sign test; statistics.

Comments are given on the paper "Treatment of Null Responses" by G. L. Meyer and R. L. Johnson at the 17th Conference on the Design of Experiments in Army Research Development and Testing. The statistical limitations imposed by small sample sizes are discussed. A change in the design of the experiment is suggested which would reduce or eliminate altogether the number of ties (due to null responses). A modification of the Sign Test is proposed which allows the processing of the data even in the presence of ties.

**14043.** Brauer, G. M., **Adhesives and composites in dentistry—present and future**, *Proc. Symp. Dental Biomaterials—Research Priorities, Des Plaines, Ill., Aug. 1973*, DHEW Publ. No. (NIH) 74-548, pp. 63-99 (Department of Health, Education, and Welfare, Bethesda, Md., 1974).

Key words: adhesion to tooth structure; adhesives; dental composites; dental restorative materials.



Probably no subject matter affects as many facets of dental biomaterials as that of the modification of and adhesion to tissues. The many techniques that are available to gain valuable information of the structure of tooth surfaces and methods to vary their characteristics are reviewed. Materials and procedures have become available that exhibit clinically significant adhesion to enamel. Bonding to collagenous surfaces such as dentin under conditions encountered in the oral cavity appears to be a realizable goal. Composite restoratives possess unusually good esthetics and their overall properties are considerably better than those of unfilled resins. Investigations of reactions at the interfaces and optimization of the ingredients, as well as the rapidly expanding wealth of experience with these materials, should lead to further improvements. For many composite restorations a nonadhesive protective liner is needed. This requirement negates the use of a tooth-composite coupling agent unless this agent protects the pulp from the noxious effects of the composite. Nonetheless, the evidence today suggests that continuing progress will lead to clinically acceptable adhesive restoratives that will substantially improve the quality of dental services.

**14044.** Tsang, W., *Pyrolysis of 2,4-dimethylhexene-1 and the stability of isobutenyl radicals*, *Int. J. Chem. Kinet.* **5**, 929-946 (1973).

Key words: bond strength; combination rate; decomposition; isobutenyl; shock tube; 2,4-dimethylhexene-1.

2,4-Dimethylhexene-1 has been decomposed in single-pulse shock tube experiments. Rate expressions for the initial reactions are

$$k(\text{C}_4\text{H}_7\text{-}s\text{-}\text{C}_4\text{H}_9 \rightarrow \text{C}_4\text{H}_7\cdot(\text{isobutenyl}) + s\text{-}\text{C}_4\text{H}_9\cdot) = 10^{15.6} \exp(-33,200/T) \text{ sec}^{-1}$$

and

$$k(\text{C}_4\text{H}_7\text{-}s\text{-}\text{C}_4\text{H}_8 \rightarrow i\text{C}_4\text{H}_8 + n\text{-}\text{C}_4\text{H}_8) = 10^{12.5} \exp(-26,900/T) \text{ sec}^{-1}$$

at 1.5-5 atm and 1050 K. This leads to  $\Delta H^\circ_{f300}(\text{CH}_2 = \text{C}(\text{CH}_3)\text{CH}_2) = 124 \text{ kJ/mol}$ , or an allylic resonance energy of 50 kJ/mol. Rate expressions for the decomposition of the appropriate olefins which yield isobutenyl radicals and methyl, ethyl, isopropyl, *n*-propyl, *t*-butyl, and *t*-amyl radicals, respectively, are presented. The rate expression for the decomposition of isobutenyl radical is

$$k(\text{C}_4\text{H}_7\cdot(\text{isobutenyl}) \rightarrow \text{C}_3\text{H}_4(\text{allene}) + \text{CH}_3\cdot) = 10^{13.3} \exp(-25,200/T) \text{ sec}^{-1}$$

(at the beginning of the fall-off region). For the combination of isobutenyl and methyl radicals, the rate constant at 1020 K is

$$k(\text{C}_4\text{H}_7\cdot(\text{isobutenyl}) + \text{CH}_3\cdot \rightarrow 2\text{-methylbutene-1}) = 10^{10.3} \text{ l./mol sec}$$

Combination of this number and the calculated rate expression for 2-methylbutene-1 decomposition gives  $S^{C_4H_7} (1100) = 470 \text{ J/mol K}$ . This yields

$$k(\text{CH}_3\cdot + \text{C}_3\text{H}_4(\text{allene}) \rightarrow \text{C}_4\text{H}_7\cdot(\text{isobutenyl})) = 10^{8.2} \exp(-2,500/T) \text{ l./mol sec}$$

It is demonstrated that an upper limit for the rate of hydrogen abstraction by isobutenyl from toluene is

$$k(\text{C}_4\text{H}_7\cdot + \phi\text{CH}_3 \rightarrow i\text{C}_4\text{H}_8 + \phi\text{CH}_2\cdot) \leq 10^{8.3} \exp(-6,000/T) \text{ l./mol sec.}$$

**14045.** Berger, M. J., Seltzer, S. M., Maeda, K., *Some new results on electron transport in the atmosphere*, *J. Atmos. Terrest. Phys.* **36**, 591-617 (1974).

Key words: atmosphere; backscattering; bremsstrahlung;

electron; energy deposition; flux spectrum; Monte Carlo calculations.

The penetration, diffusion and slowing down of electrons in a semi-infinite air medium has been studied by the Monte Carlo method. The results are applicable in the atmosphere at altitudes up to  $\sim 300 \text{ km}$ . Most of the results pertain to monoenergetic electron beams, with energies between 2 keV and 2 MeV, injected into the atmosphere at a height of 300 km, either vertically downwards or with a pitch-angle distribution isotropic over the downward hemisphere. Some results were also obtained for various initial pitch angles between 0 and 90°. Information has been generated concerning the following topics: (a) the backscattering of electrons from the atmosphere, expressed in terms of backscattering coefficients, angular distributions and energy spectra; (b) the altitude dependence of energy deposition by electrons and by secondary bremsstrahlung, for incident electron beams that are monoenergetic or have exponential spectra with e-folding energies between 5 and 200 keV; (c) the evolution of electron flux spectra as function of the atmospheric depth, for incident beam energies between 2 and 20 keV.

**14046.** Tsang, W., *Comparisons between experimental and calculated rate constants for dissociation and combination reactions involving small polyatomic molecules*, *Int. J. Chem. Kinet.* **5**, 947-963 (1973).

Key words: ammonia; combination; cyanogen; decomposition kinetics; nitric acid; nitril chloride; ozone; RRKM.

The experimental results on decomposition and combination reactions involving  $\text{O}_3$ ,  $\text{HNO}_3$ ,  $\text{NH}_3$ ,  $\text{C}_2\text{N}_2$ , and  $\text{NO}_2\text{Cl}$  over extended temperature and pressure ranges are compared with the deductions from RRKM calculations. Quantitative fits of the data over the entire range are possible only if the external (overall) rotations are assumed to be involved in the reactions. Recommended rate constants for the reactions  $\text{O} + \text{O}_2 + \text{N}_2 \rightarrow \text{O}_3 + \text{N}_2$  and  $\text{OH} + \text{NO}_2 + \text{N}_2 \rightarrow \text{HNO}_3 + \text{N}_2$  are presented.

**14047.** Pummer, W. J., Wall, L. A., *The burning and thermal properties of some  $\gamma$ -irradiated polymers*, *Proc. 165th Dallas Meeting of the American Chemical Society—Division of Organic Coatings and Plastic Chemistry, Dallas, Texas, Apr. 8-13, 1973*, **33**, No. 1, 490-498 (1973).

Key words: combustion; DTA;  $\gamma$ -irradiation; LOI; polymers; TGA.

Very little data are available which are concerned directly with the burning characteristics of  $\gamma$ -irradiated polymers. In this report, samples of six commercially available polymers were exposed to  $\gamma$ -rays from a cobalt-60 source for 24 and 72 hour periods of time. Data was collected and compared between the nonirradiated and exposed polymers in the following areas: (1) the limiting oxygen index values, (2) the differential thermal analysis, (3) thermogravimetric analysis, and (4) temperature profiles of the polymers burning at or near their oxygen index values. The behavior of the polymers towards  $\gamma$ -rays is dependent upon the structure of each polymer. For example, Plexiglas (PMMA), Celcon (acetal copolymer), and poly- $\alpha$ -methylstyrene are degraded by  $\gamma$ -rays, while polystyrene, polyethylene, and Surlyn A ionomer undergo mainly crosslinking types of reactions although some degradation may also occur in the latter two polymers. In turn, the changes that may occur in thermal properties of the  $\gamma$ -treated polymers depend upon the severity of the radiation damage caused by the  $\gamma$ -rays to the polymers under our conditions of exposure. The amount of radiation damage sustained by each polymer would also be expected to affect the burning characteristics of each polymer. Thus, Celcon and Plexiglas, severely degraded by  $\gamma$ -rays, show the largest variations in their LOI values. Polystyrene, poly- $\alpha$ -methylstyrene and the ionomer, show no changes in their values after  $\gamma$ -irradiation, and



polyethylene shows a slight rise in the LOI value on longer exposure times.

- 14048.** Yakowitz, H., **X-ray microanalysis in scanning electron microscopy**, *Proc. Annual Scanning Electron Microscopy Symp. sponsored by IITRI, Chicago, Ill., Apr. 7-9, 1974*, pp. 1029-1042 (IIT Research Institute, Chicago, Ill., Apr. 1974).

Key words: analytical accuracy; electron probe microanalysis; elemental mapping; energy dispersive analysis; scanning electron microscopy; specimen preparation.

This tutorial paper touches briefly on a number of aspects of qualitative and quantitative x-ray analysis. The way in which energy dispersive detectors can be used for qualitative and quantitative analysis is described. Automatic qualitative analysis and background subtraction for energy dispersive methods are described. Crystal spectrometer systems are considered and compared with energy dispersive techniques. The question of identification and analysis of elements of atomic number eleven or less is discussed. A great many practical problems can be solved by elemental distribution mapping. Therefore, this technique is outlined and an example given. A brief compendium of the classical theoretical basis for quantitative analysis is given; histograms of results indicate what accuracy can be expected from optimum specimens. Other quantitative analysis methods such as the hyperbolic approximation are also touched upon. An on-line quantitative analysis computer routine is outlined. Special specimen geometries such as thin films, either free standing or on a substrate or small spheres, or inclusions require special handling. Finally, a few comments on specimen preparation are offered.

- 14049.** Fathers, D. J., Jakubovics, J. P., Joy, D. C., Newbury, D. E., Yakowitz, H., **A new method of observing magnetic domains by scanning electron microscopy. I. Theory of the image contrast**, *Phys. Status Solidi* **20**, 535-544 (1973).

Key words: contrast measurement; image contrast; iron-silicon alloy; magnetic domains; nickel; scanning electron microscopy.

A theory is developed to explain the magnetic domain contrast observed by scanning electron microscopy using the method reported recently. The theory is based on a model which assumes that the contrast is due to the Lorentz deflection of the incident electrons inside the specimen. Using this model, the dependence of the image contrast on various experimental parameters was calculated analytically. The model was confirmed by means of calculations carried out by computer simulation of electron trajectories (Monte Carlo techniques). The theory accounts satisfactorily for previous experimental results. A more detailed comparison of the theory with experimental results will be published in a subsequent paper.

- 14050.** Marcus, M., Merris, R., **A relation between the permanent and determinantal adjoints**, *J. Australian Math. Soc.* **XV**, Pt. 3, pp. 270-271 (1973).

Key words: congruence; doubly stochastic matrix; positive definite hermitian matrix.

Let  $A$  be an  $n$ -square positive definite hermitian matrix and  $A(i|j)$  be the submatrix of  $A$  obtained by deleting row  $i$  and column  $j$ . Let  $P(A)$  be the  $n$ -square matrix whose  $ij$  entry is  $\text{per } A(j|i)$ . If  $D(A)$  is the classical adjoint of  $A$  then  $n(\text{per } A)D(A) - (\det A)P(A)$  is positive semidefinite.

- 14051.** Kessler, K. G., **Progress in the measurement of atomic transition probabilities and solar abundances**, *Comments At. Mol. Phys.* **11**, No. 5, Part D, 151-155 (Dec. 1970-Jan. 1971).

Key words: astrophysics;  $f$ -values; oscillator strengths; transition probabilities.

The exploitation, over the past decade, of new approaches to the measurement of atomic transition probabilities has produced data of greater accuracy than was available before. The value of these new data to astronomy is well illustrated by the recent work on the iron spectrum. Though it is a somewhat atypical example, it serves as an excellent illustration of the great progress in this field and its effect on astrophysics.

- 14052.** Wells, J. S., McDonald, D. G., Risley, A. S., Jarvis, S., Cupp, J. D., **Spectral analysis of a phase locked laser at 891 GHz, an application of Josephson junctions in the far infrared**, *Rev. Phys. Appl.* **9**, 285-292 (Jan. 1974).

Key words: frequency noise; HCN laser; infrared frequency synthesis; Josephson junction; laser frequency measurements; laser linewidth; laser stabilization; phase locked laser.

We have used a Josephson junction to investigate the spectral purity of an HCN laser which is used in an infrared frequency synthesis chain. To obtain a narrower linewidth from the laser it has been phase locked to a multiplied microwave reference chain. A calculated value for this linewidth was based upon the measured noise spectrum of the microwave source and a theory due to Middleton. One can take advantage of the unique properties of the Josephson junction as a frequency multiplier and mixer for use in measuring this linewidth. The Josephson junction is driven by an x-band signal which is derived from a specially designed cavity stabilized klystron system of high spectral purity. The 92nd harmonic of the x-band signal is generated in the Josephson junction. In addition, the Josephson junction acts as a mixer of the harmonic signals and the 891 GHz output of the HCN laser. The 92nd harmonic beat signal is taken from the Josephson junction, amplified, and sent to a spectrum analyzer for frequency domain analysis. Details of the experiment, results, and relation to predicted linewidths are presented.

- 14053.** Schoenwetter, H. K., **An ultra-stable ac power supply for an absolute volt determination**, *Metrologia* **10**, No. 1, 11-15 (Mar. 1974).

Key words: absolute volt experiment; feedback control system; power amplifier; power supply oscillator; stable ac supply; voltage monitor.

A 159.2 Hz power supply with 85 VA power output and very stable amplitude was designed and constructed for use in an absolute volt experiment. The rms value of the ac voltage is regulated at the level of a dc reference voltage (based on unsaturated standard cells), using a feedback control circuit. The measured amplitude drift is less than 0.5 ppm/h and is typically less than 1 ppm in 4 h. The measured amplitude temperature coefficient is 0.6 ppm/°C and the distortion is less than 0.02 percent.

- 14054.** Wagner, H. L., Hoeve, C. A. J., **Mark-Houwink relations for linear polyethylene in 1-chloronaphthalene and 1,2,4-trichlorobenzene**, *J. Polymer Sci.* **11**, 1189-1200 (1973).

Key words: fractionation; limiting viscosity number; linear polyethylene; Mark-Houwink; molecular weight; Stockmayer-Fixman; unperturbed dimensions; viscosity; 1-chloronaphthalene; 1,2,4-trichlorobenzene.

The parameters in the Mark-Houwink relationship,  $[\eta] = K' M_v^a$ , for linear polyethylene in 1-chloronaphthalene and 1,2,4-trichlorobenzene at 130 °C have been estimated. They were found by measuring the limiting viscosity numbers of a series of fractions with molecular weights ranging from less than 10,000 to almost 700,000. The results are for 1-chloronaphthalene,  $[\eta] = 0.0555 M_v^{0.684}$  (with a standard error of 0.0064 in  $K'$  and 0.010 in  $a$ ) and for 1,2,4-trichlorobenzene,  $[\eta] = 0.0392 M_v^{0.725}$  (with a standard error of 0.00703 in  $K'$  and 0.015 in  $a$ ), where  $[\eta]$  is expressed in ml/g. The unperturbed end-to-end distance calcu-



lated from the viscosity-molecular weight data agrees with the theoretically expected value.

- 14055.** Ruff, A. W., **Grain orientation dependence of reactivity in polycrystalline titanium after anodic polarization**, *Met. Trans.* **5**, 601-603 (Mar. 1974).

Key words: corrosion; crystallographic orientation; electrochemical polarization; electron channeling; titanium.

Selected area electron channeling patterns were obtained from individual grains down to 10  $\mu\text{m}$  size in polycrystalline titanium after different anodic polarization treatments in 1 N  $\text{H}_2\text{SO}_4$ . The crystallographic orientations of the more resistant and less resistant grains were determined and correlated with their relative reactivity. The results were in agreement with previously reported single crystal studies on titanium.

- 14056.** Colwell, J. H., **The heat capacity of cerous magnesium nitrate and some related materials between 0.3 and 4 K**, *J. Low Temp. Phys.* **14**, Nos. 1/2, 53-71 (Jan. 1974).

Key words: cerous magnesium nitrate; heat capacity; magnetic thermometry and adiabatic cooling.

Cerous magnesium nitrate (CMN) is the preeminent electronic paramagnet in use in cryogenic physics for magnetic thermometry and adiabatic cooling. In demagnetization experiments designed to establish the thermodynamic temperature relations for CMN, an inexplicable heat capacity anomaly was found to occur above 20 mK and is shown here to persist to temperatures near 1 K. The anomaly is small but its presence interferes with and may cause errors in the analysis of thermometric data. We have measured the heat capacity of CMN, lanthanum magnesium nitrate (LMN), cerous nitrate hexahydrate, and a saturated aqueous solution of CMN (CMN liquor) in the temperature range 0.3-4 K in an attempt to find the source of the anomaly. The LMN heat capacity shows no anomaly and is used to approximate the lattice heat capacity of CMN. At low temperatures the CMN heat capacity, exclusive of the lattice contribution, is some 2 1/2 times larger than the magnetic heat capacity predicted by other investigations. At high temperatures an exponentially increasing heat capacity due to the first excited electronic level is observed and indicates a splitting which is in accurate agreement with the spectroscopic value. There is evidence that the lattice heat capacity in CMN is about 1 percent smaller than in LMN, which is probably the result of the crystal-field interaction with the electronic states of the cerous ions. The lattice terms and the  $T^{-2}$  term of the magnetic heat capacity for cerous nitrate have been determined, the latter being 25 times larger than the predicted  $T^{-2}$  term in CMN. The CMN liquor measurements indicate that this sample had probably become a glass on cooling. The lattice heat capacity is considerably larger than could be predicted from the separate components and there is no indication of the exponential term which would be observable if appreciable crystalline CMN were present. These measurements help to define the nature of the anomalous heat capacity and remove from consideration some possible explanations, but they do not reveal the cause of the anomaly.

- 14057.** Soulen, R. J., Finnegan, T. F., **A microwave resistive SQUID for noise thermometry**, *Rev. Phys. Appl.* **9**, No. 1, 305-307 (Jan. 1974).

Key words: Josephson junction; superconductivity; temperature.

A SQUID magnetometer has been shown to work at 10 GHz with a significant enhancement of signal-to-noise over 30 MHz devices. This article describes how such enhancement could lead to faster determinations of absolute temperature using a resistive SQUID, i.e., a noise thermometer. A prototype 10 GHz resistive SQUID is described and its performance evaluated. The feasibility of using a 10 GHz system is clearly established.

- 14058.** Chandler, H. H., Bowen, R. L., Paffenbarger, G. C., Mulineaux, A. L., **Clinical evaluation of a tooth-restoration coupling agent**, *J. Am. Dental Assoc.* **88**, 114-118 (Jan. 1974).

Key words: clinical evaluation; clinical research; composite restorations; dental restorations; dentistry; monomers; operative dentistry; reinforcements.

The clinical effectiveness of a tooth-restoration coupling agent (NPG-GMA) was tested by treatment of 54 Class III and V cavity preparations with an acetone solution of this surface-active comonomer. Fifty-four additional preparations were treated with acetone alone for comparison. The teeth were restored with an experimental composite material.

The restorations were observed by three dentists for 3 1/2 years. The evaluations indicated that the restorations placed over the NPG-GMA coupling agent had significantly better margins, and a significantly higher number of the NPG-GMA associated restorations were rated better compared to those placed over the acetone control.

- 14059.** Unassigned.

- 14060.** Hanson, D. W., Hamilton, W. F., Gatterer, L. E., **The NBS frequency and time satellite experiment using ATS-3**, *Proc. 3d Precise Time and Time Interval Strategic Planning Meeting, Washington, D.C., Nov. 16-18, 1971*, pp. 155-165 (U.S. Naval Observatory, Washington, D.C., 1971).

Key words: frequency; satellites; time.

A frequency and time dissemination experiment using NASA's ATS-3 synchronous satellite is explained. Details of frequency, bandwidth, receiving equipment requirements and recovery techniques are given to allow reader to use system. Results and data concerning accuracy and expected performance are included.

- 14061.** Sadowski, W. L., Lozier, D. W., **A unified standards approach to algorithm testing**, (Proc. ACM SIGPLAN Symp. on Computer Program Test Methods, Chapel Hill, N.C., June 21-23, 1972), Paper in *Program Test Methods*, Part VIII, pp. 277-290 (1973).

Key words: algorithms; mathematical functions; performance; standards; testing; validation.

A system of standards is proposed for the testing and validation of mathematical function subroutines. The system is based on a standards chain of the type that has been used successfully in metrology. This chain consists of a primary standard, a transfer standard, and a working standard. Their main characteristics are described and examples are given to illustrate the considerations that determine the writing of each of the above standards. The validation and testing process with the aid of these standards is discussed.

- 14062.** Leasure, W. A., Jr., **Performance evaluation of personal noise exposure meters**, *Sound Vib.* **8**, No. 3, 36-40 (Mar. 1974).

Key words: exposure meters; noise; meters noise exposure; noise exposure meters; personal noise exposure meters.

The promulgation of Federal occupational noise exposure regulations has resulted in a proliferation of personal noise exposure meters. A wide variation in performance has been observed among the various instruments; therefore, the user should be cautioned to carry out enough evaluation tests to determine that the devices are performing adequately for his purpose.

- 14063.** Molino, J. A., **Psychophysical verification of predicted interaural differences in localizing distant sound sources**, *J. Acoust. Soc. Amer.* **55**, No. 1, 139-147 (Jan. 1974).

Key words: auditory localization; diffraction patterns; earphone simulation; human audition; interaural dif-



ferences; minimum audible angle; psychometric functions; psychophysics; space perception.

Subjects made forced choices to either side of a reference direction (0, 30, 60, and 75°) to locate the image of pure tones presented through earphones. Various combinations of interaural intensity differences (IID's) and interaural time differences (ITD's) were used, including some combinations which do not occur in nature. Psychometric functions confirmed the expected apparent azimuth of ITD/IID combinations based on free-field diffraction theory and microphone measurements. The relative dominance of the intensive and temporal cues was examined at each frequency (500, 1000, and 8000 Hz). The shape of the psychometric plane for the bidimensional matrix at the 1000-Hz 30° condition showed possible nonlinearities in the trading relation. Data were also collected from the same subjects using the same signals presented by means of distant loudspeakers in an open field. When the free-field data were compared with the data from ear-phone-simulated sounds, they showed similar angular acuities, being approximately the size of those reported in the literature.

**14064.** DiMarzio, E. A., **Statistical mechanics of polymers with application to a polymer between plates**, (XXIII Int. Congress of Pure and Applied Chemistry, Special Lectures, Boston, Mass., July 26-30, 1971), *J. Pure Appl. Chem.* **8**, 239-263 (1971).

Key words: polymer statistics; statistical mechanics of polymers.

It is shown that the customary separation of the classical partition function into a translational part and a configurational part is invalid for polymers. However, the integration over momentum coordinates can always be performed resulting in a configuration integral with effective potential energies. The problem of a polymer molecule near a surface of arbitrary shape is formally solved. The polymer is allowed to experience a spatially varying potential ( $V(r)$  per segment). Kakutani's theorem of probabilistic potential theory is easily derived. Using both continuum and lattice methods explicit formulae are obtained which describe the behavior of a polymer molecule constrained to be (1) on one side of an infinite plate, or (2) between two parallel plates, or (3) in a wedge of arbitrary angle. These results are applied to the problems of adsorption and adhesion and to the problem of crystallization. It is shown how an understanding of these subjects requires prerequisite knowledge of the appropriate polymer-interface problem. The notion of polymer size is not invariant but rather depends on the process in which the polymer participates. If one thrusts a plate towards another plate on which a polymer molecule resides until a first contact is made then the resulting plate separation defines a polymer size which is relevant to the problems of adhesion and crystallization. It is larger than the root-mean-square end-to-end length.

**14065.** Fatiadi, A. J., **Electron spin resonance studies of chemical changes of phenylhydrazones and osazones in alkaline solution**, *Adv. Chem. Ser.*, No. 117, *Carbohydrates in Solution*, pp. 88-105 (1973).

Key words: alkaline solution; chemical changes; electron spin resonance; free radical mechanism; nitroxide radical; osazones; phenylhydrazones.

Treatment of a solution of a sugar phenylhydrazone or osazone in methyl sulfoxide with potassium *tert*-butoxide and a trace of oxygen at room temperature gives products that have a three-line electron spin resonance (ESR) spectrum characteristic of a nitroxide radical. The apparent fragmentation of the phenylhydrazine moiety under reaction conditions used does not show evidence of any paramagnetic species derived from glyoxal bis(phenylhydrazone). The latter had been reported to be the product of degradation of the sugar phenylhydrazones under

more vigorous alkaline treatment. Some inosose phenylhydrazones in alkaline methyl sulfoxide solution produce stable radical-anions in which the phenylhydrazine moiety remains intact. A free radical mechanism is advanced to account for the  $\beta$ -elimination reactions of the sugar phenylhydrazones under mildly basic conditions.

**14066.** Giarratano, P. J., **Supercritical helium heat transfer**, (Proc. CRYO-72 Conf., Chicago, Ill., Oct. 3-5, 1972), Chapter 4 in *Applications of Cryogenic Technology* **5**, 52-89 (Scholium Int. Inc., Whitestone, N.Y., 1973).

Key words: forced convection; heat transfer; helium; supercritical.

This paper reports part of the National Bureau of Standards Cryogenics Division's program to provide helium heat transfer information to designers of helium cooling systems. An experiment on supercritical helium heat transfer is described, and its results are compared with various standard and modified correlation expressions.

Extensive appendices give tables of helium viscosity, thermal conductivity, and Prandtl numbers from 3 to 300 K.

**14067.** Hall, J. L., **Saturated absorption line shape**, *Proc. Esfahan Symp. on Fundamental and Applied Laser Physics, Esfahan, Iran, Sept. 1971*, pp. 463-477 (1972).

Key words: laser spectrometer; pressure broadening; resonance line shape; saturated absorption.

In this paper we demonstrate optical frequency stability of  $\pm 3 \times 10^{-14}$  obtained at 3.39  $\mu\text{m}$  by use of saturated molecular absorption in methane. Through Frequency Offset Locking this stability can be transferred to other lasers, thus allowing construction of a very powerful laser spectrometer. A resolution of  $2 \times 10^9$  FWHM and absolute resettability of  $\pm 1/2 \times 10^{-11}$  have been achieved with this spectrometer. We have studied the power- and pressure-broadening of saturation resonances in methane for several different laser spot sizes. Except near zero power and pressure, the line shape is found to be accurately Lorentzian. Based on a saturation model, a 3-parameter formula is presented which accounts for the observed broadening. The residual line width (intercept at zero power and pressure, HWHM) times laser spot radius is found to be 70 kHz mm. The saturation power turns out to be 1 mW. Pressure broadening rates of 10 to 16 kHz (HWHM)/mT are observed.

**14068.** Haller, W., **A single equation relating molecular weight, pore-size, and elution coefficient in the controlled pore glass chromatography of protein-sodium dodecyl sulfate complexes**, *J. Chromatog.* **85**, 129-131 (1973).

Key words: chromatography; controlled pore glass; denaturing solvents; glass; molecular weight; permeation; porous glass; proteins; sodium duodecyl sulfate.

Permeation chromatography elution coefficients of the sodium duodecyl sulfate complexes of thirteen different proteins on controlled pore glass columns were analyzed. A master equation, relating elution coefficient, subunit molecular weight and pore diameter of glass is described. The equation allows estimating the subunit molecular weight of the proteins from elution results on columns of any known pore diameter, without the need for individual column calibration with a series of proteins with known subunit molecular weight.

**14069.** Cuthill, J. R., Dobbyn, R. C., McAlister, A. J., Williams, M. L., **Critical evaluation of soft x-ray emission spectra: Al metal**, *Proc. Int. Symp. X-Ray Spectra and Electronic Structure of Matter, Munchen, Germany, Sept. 18-22, 1972*, **II**, 208-219 (1973).



Key words: aluminum; critical evaluation; emission spectra; metals; soft x ray.

Measurements of the K and L valence band emission spectra of Al metal are critically compared in the light of current theory and experimental practice, and with the results of ultraviolet photoemission. The picture which emerges is one of essential agreement of experiment with one electron band theory. A number of discrepancies are noted within the existing body of data, and ascribed to inconsistencies in experimental practice.

**14070.** McAlister, A. J., Cuthill, J. R., Williams, M. L., Dobbyn, R. C., **Electronic structure of the diborides of the 3d metals**, *Proc. Int. Symp. X-Ray Spectra and Electronic Structure of Matter, Munchen, Germany, Sept. 18-22, 1972*, **II**, 426-448 (1973).

Key words: band structure; borides; density of states; emission spectra; soft x ray; transition metal diborides.

Reported here are the results of two studies of the electronic structure of the isostructural sequence of refractory hard metals  $\text{ScB}_2$ ,  $\text{TiB}_2$ ,  $\text{VB}_2$ , and  $\text{CrB}_2$ . Experimentally, we have obtained the Boron soft x-ray K-emission spectra of the series and, as in other physical properties, observed a systematic variation with metal atomic number. Computationally, we have carried out a model band calculation which predicts qualitatively both the observed soft x-ray behavior and other observed trends in the properties of these compounds.

**14071.** Mann, D. B., Diller, D. E., Olien, N. A., Hiza, M. J., **Measurements of liquefied natural gas in commerce**, *Proc. American Gas Association Operating Section, El Paso, Texas*, pp. D-206—D-214 (American Gas Association, Inc., Arlington, Va., 1973).

Key words: cryogenic; density; flow; importation; liquefied natural gas; measurement; methane.

The Cryogenics Division of the NBS Institute for Basic Standards is currently involved in a number of programs dealing with liquefied natural gas (LNG). The objective of these NBS programs is to bring to bear over 20 years of cryogenic experience on certain selected LNG problem areas. A description of the programs will be given in the following sections as well as a summary of progress of this five-year effort.

In addition, the objectives of past, present and projected LNG programs at NBS will be related to one specific LNG problem area, custody transfer, and suggestions will be made about maximum utilization of present and expected research results.

**14072.** Penn, D. R., **Field emission from adsorbate covered surfaces. II**, *Phys. Rev. B* **9**, No. 3, 844-847 (Feb. 1, 1974).

Key words: adsorbate density of states; adsorbate energy level; chemisorb; field emission; surface; total electronic energy distribution.

A previous calculation of the total energy distribution of field-emitted electrons in the presence of chemisorbed atoms by Penn, Gomer, and Cohen (PGC) is reexamined with respect to the following point. PGC assumed that the metal-adsorbate system could be represented by the Anderson model; however, the Anderson model is phenomenological. Anderson and McMillan have shown how the model can be reformulated in a way which makes it more quantitative. Use of the reformulated model leads to a significant change in the PGC result for the field-emission current. We find  $\Delta j(\omega)/j_0(\omega) = R^{-1}u'^2\rho_a$ , where  $\Delta j(\omega)$  is the change in the current at energy  $\omega$  due to the presence of the adsorbate and  $j_0(\omega)$  is the current in the absence of the adsorbate.  $\rho_a$  is the density of states at the adsorbate and  $u'^2$  and  $R^{-1}$  are given in the text. This result differs from that of PGC by the factor  $R = [1 + \xi^{3/2}(\pi\alpha)^{-1/2}]^2$ , where  $\xi = (-2mE_F/\hbar^2)^{1/2}$  and  $\alpha = 2mEF/\hbar^2$ . Energies are measured from the vacuum level,  $E_F$  is the metal Fermi

energy, and  $F$  is the strength of the external electric field. For typical experimental conditions  $R^{-1} \approx 1/16$ .

**14073.** Bennett, L. H., Swartzendruber, L. J., Watson, R. E., **Critical temperatures in Fe-doped copper-rich Cu-Ni alloys**, (Proc. 17th AIP Conf. on Magnetism and Magnetic Materials, Chicago, Ill., Nov. 15-18, 1971), Chapter in *Magnetism and Magnetic Materials*, C. D. Graham, Jr., and J. J. Rhyne, Eds., No. 5, pp. 1190-1194 (June 1972).

Key words: alloys; copper; critical temperatures; iron; magnetism; Mössbauer effect; nickel.

Systematics of magnetic ordering as a function of Fe and Ni content have been investigated by use of the Mössbauer effect in Cu-based alloys with up to a few percent Fe and up to 40 percent Ni. The halfwidth of the magnetic transition is  $\sim 1$  K in all the "weak" ferromagnets (i.e., when the critical temperature,  $T_c \leq 10$  K), and is a similar, or smaller, fraction of  $T_c$  for the strong ferromagnets.  $T_c$  is sharply defined for all compositions, despite the distribution of hyperfine fields and magnetic moments existing in these alloys. For any Ni concentration,  $T_c$  increases with increasing Fe. As a function of Ni, a minimum in  $T_c$  occurs near 30 percent Ni. These results indicate that the long-range conduction electron interaction between Fe atoms in Cu is reduced by Ni addition, with strong short-range interactions becoming more important for ferromagnetism at higher Ni concentrations.

**14074.** Wachtman, J. B., Jr., **Determination of elastic constants required for application of fracture mechanics to ceramics**, (Proc. Symp. on Fracture Mechanics of Ceramics, University Park, Pa., July 11-13, 1973), Paper in *Fracture Mechanics of Ceramics*, R. C. Brandt, D. P. H. Hasselman, and F. F. Lange, Eds., **1**, 49-68 (Plenum Publishing Corp., New York, N.Y. 1974).

Key words: anisotropy; elastic constants; elasticity; fracture; fracture mechanics; Griffith criterion.

Elastic properties enter into fracture mechanics most simply in the case of plane stress in an elastically isotropic body for which  $EG_1 = \Pi K_1^2$  where  $G_1$  is the energy release rate,  $K_1$  is the stress intensity factor, and  $E$  is Young's modulus. For an elastically orthotropic body the same result holds provided  $1/E$  is replaced by  $(s_{11}s_{22}/2)^{1/2} [s_{22}/s_{11}]^{1/2} + (2s_{12} + s_{66})/2s_{11}]^{1/2}$  where the  $s_{ij}$  are the single crystal elastic compliances. These equations may be used to establish a Griffith type fracture criterion by setting  $G_1 = G_{1c} = 2\gamma_f$  where  $\gamma_f$  is the fracture surface energy. Elastic moduli or compliances can usually be determined more accurately than either  $G_{1c}$  or  $\gamma_f$ . Methods for their determination by resonance or by ultrasonic wave propagation are briefly described. Values of the elastic factors in the energy release rates for material in polycrystalline form are compared with values for materials in single crystal form for various orthotropic orientations of cracks to indicate the effectiveness of single crystal elastic isotropy in causing variation in the fracture condition. This theory is shown to predict an anisotropic fracture criterion for certain crystal planes.

**14075.** Allan, D. W., Gray, J. E., Machlan, H. E., **The National Bureau of Standards atomic time scale: Generation, dissemination, precision, and accuracy**, (Proc. Conf. Electromagnetic Measurement, Boulder, Colo., June 26-29, 1972), *1972 CPEM Digest*, p. 165 (1972).

Key words: atomic clock; cesium clock; coordinate time; Flicker noise; frequency standard; time dissemination; time scale.

The atomic time scale at the National Bureau of Standards, AT(NBS), depends upon an ensemble of continuously operating cesium clocks calibrated occasionally by the NBS primary frequency standard. The data of interclock comparisons and frequency calibrations are statistically processed to provide near



optimum time stability and frequency accuracy. Each clock is represented by a simple mathematical model of its noise spectrum, with parameters determined by the behavior of that clock. These noise parameters are used in a nearly optimum procedure for periodically recalibrating the frequency of each clock and for combining the clock readings to produce AT(NBS). The long-term fractional frequency stability of AT(NBS) is shown to be a few parts in  $10^{14}$ , and the accuracy is inferred to be 1 part in  $10^{12}$ .

A small coordinate rate is added to the rate of AT(NBS) to generate UTC(NBS); this small addition is for the purpose of maintaining synchronization within a few microseconds of other international timing centers. UTC(NBS) is readily and operationally available over a large part of the world via WWV, WWVH, WWVB, and telephone; also via some time transfer systems, e.g., Loran-C and the TV line-10 system; and also experimentally via satellite and WWVL. The precision and accuracy of these dissemination systems will be discussed.

**14076.** Hunt, C. M., **Simple observations of some common indoor activities as producers of airborne particulates**, (Proc. ASHRAE Symp. Cleaner Indoor Air—Progress and Problems, Cincinnati, Ohio, Oct. 19-22, 1972), Chapter in *ASHRAE*, pp. 8-14 (American Society of Heating, Refrigerating, and Air-Conditioning Engineers, New York, N.Y., 1973).

Key words: air cleaning; air pollution; dust generation; indoor pollution; particulates.

Observations were made of some common indoor particle generating and dispersing activities by performing them in a small closed room and measuring the changes in particle count as a function of time using a light scattering particle counter. Two size ranges were measured, particles larger than  $0.3\ \mu\text{m}$  in diameter, and particles larger than  $3\ \mu\text{m}$ . The activities examined were smoking, heating grease as in frying, operation of a vacuum cleaner, and use of household aerosol sprays. The particle count in a closed room without activity was also observed as well as the effect of an oscillating electric fan.

Thermal operations such as smoking and the heating of grease produced a much larger number of particles smaller than  $3\ \mu\text{m}$  than the mechanical generating and dispersing activities. The mechanical activities, by comparison, tended to produce more particles larger than  $3\ \mu\text{m}$ . With no activity in the room the particle count in both size ranges decreased with time, and with the electric fan or vacuum sweeper operating an increase in particle count was observed, followed by a decrease qualitatively similar to that observed with no activity in the room. The increase in count by the aerosol sprays appeared to be dominated by effects due to the propellant.

**14077.** Lyerla, J. R., Jr., McIntyre, H. M., Torchia, D. A., **A  $^{13}\text{C}$  nuclear magnetic resonance study of alkane motion**, *Macromolecules* **7**, 11-14 (Jan.-Feb. 1974).

Key words: alkanes; carbon-13; magnetic resonance; molecular motion; polyethylene; rotational potentials; spin-lattice relaxation.

Carbon-13 spin-lattice relaxation times ( $T_1$ ) have been measured for resolved carbons in neat *n*-alkanes ( $n = 7, 10, 13, 15, 18, 20$ ) and 2-methylnonadecane, and effective correlation times ( $\tau_{\text{eff}}$ ) have been calculated from the  $T_1$  values. A self-consistent analysis of the  $\tau_{\text{eff}}$  values is provided using a model which considers alkane carbon motion in terms of contributions from overall and internal rotations. This analysis yields values for the barriers to methyl rotation in the linear (2.6 kcal/mol) and branched (2.9 kcal/mol) alkanes that are in approximate agreement with previously reported values. One also obtains information on the effects of chain ends and branches on internal motion and an estimate of the number of carbons involved in segmental motion of long alkanes.

**14078.** VanderHart, D. L., **Low capacitance electrical feedthrough and simple, reusable closure seal for hydrostatic pressures to 7 kilobar and temperatures to 200 °C: Application to NMR**, *Rev. Sci. Instrum.* **45**, No. 1, 111-113 (Jan. 1974).

Key words: closure seal; electrical feedthrough; high pressure; hydrostatic; NMR; temperature.

An electrical feedthrough having a capacitance of 7 pF is described. It consists of a stack of two right circular cylinders, one an insulator, and one a metal with polyimide gaskets appropriately placed. A very simple, reusable, polymeric closure seal is also described. The seal is patterned after the "C" seal and features easy extraction and sealing on the small bore of the pressure vessel. The closure seal and feedthrough have been tested to 7 kilobar at room temperature and 5 kilobar at 200 °C without failure.

**14079.** Zwanzig, R., Bishop, M., **Tunnel model of liquid diffusion**, *J. Chem. Phys.* **60**, No. 1, 295-296 (Jan. 1974).

Key words: liquid diffusion; tunnel model; velocity correlation function.

A tunnel model of liquid diffusion, analogous to Barker's thermodynamic model, is constructed by separating particle motion into components parallel and perpendicular to a tunnel axis. By combining exact results for hard rod systems, one is able to predict both the tunnel diffusion coefficient and the corresponding velocity correlation function. The ratio of the tunnel diffusion coefficient to the Enskog value at the same density and temperature is obtained by matching the virial and the temperature. The value predicted lies outside the range investigated by Alder *et al*; therefore direct comparison to molecular dynamics results is not possible. However, the velocity correlation function has the negative region characteristic of dense fluids. It is suggested that the derivation of the tunnel model dynamics may be valid at close packed densities.

**14080.** Beatty, R. W., **2-Port  $\lambda_c/4$  waveguide standard of voltage standing-wave ratio**, *Electronics Letters* **9**, No. 2, 24-26 (Jan. 25, 1973).

Key words: coaxial line; impedance standard; reflection coefficient standard; VSWR standard; waveguide.

A new calculable standard of voltage-reflection coefficient and voltage standing-wave ratio consists of a quarter-guide-wavelength section of waveguide having cross-sectional dimensions different from those of the waveguide system into which it is inserted. Design equations are given for waveguide of rectangular and coaxial cross-sections.

**14081.** Frederikse, H. P. R., Hosler, W. R., **Electrical conductivity of MHD-channel materials**, *Proc. 14th Symp. on Engineering Aspects of Magnetohydrodynamics*, Tullahoma, Tenn., Apr. 8-10, 1974, pp. IV.2.1-IV.2.3 (1974).

Key words: coal slag; electrical conductivity; high temperature; magnetohydrodynamics; zirconates.

This paper deals with two aspects of MHD-channel materials. The first part reports on the electrical conductivity of mixtures of coal slag and  $\text{K}_2\text{SO}_4$  seed. The second part discusses the problem of finding electronically conducting electrode materials and describes the results of conductivity measurements performed on Ce and Ti doped  $\text{SrZrO}_3$ .

**14082.** Candela, G. A., Forman, R. A., Kahn, A. H., Meadowcroft, D. B., Wimmer, J., **Magnetic susceptibility of lanthanum chromite doped with strontium**, *Proc. 14th Symp. on Engineering Aspects of Magnetohydrodynamics*, Tullahoma, Tenn., Apr. 8-10, 1974, pp. IV.5.1-IV.5.3 (1974).

Key words: lanthanum chromite; lanthanum strontium chromite; magnetic susceptibility.



The magnetic susceptibility of sintered samples of Sr doped  $\text{LaCrO}_3$  has been measured over the temperature range of 2 K to 365 K. All the samples were antiferromagnetic at low temperatures. Above 300 K all the doped samples exhibited a lower susceptibility than the pure material. Analysis of these results showed that in the doped samples not all of the chromium is in the  $3^+$  oxidation state. These results support the view that Sr doping modifies the valence of the Cr and thereby enhances the electronic conduction.

**14083.** Becker, D. A., LaFleur, P. D., **Characterization of a nuclear reactor for neutron activation analysis**, (Proc. Int. Conf. on Modern Trends in Activation Analysis, Saclay, France, Oct. 1972), *J. Radioanal. Chem.* **19**, 149-157 (1974).

Key words: cadmium ratio; fast neutron flux; neutron activation analysis; sample pressure; thermal neutron flux; threshold foil.

Evaluation of some of the neutron activation analysis irradiation characteristics for the NBS Nuclear Reactor (NBSR) are reported, along with a description of a measurement technique developed. The characteristics discussed here are the thermal (sub-cadmium) neutron flux determination, neutron energy distribution measurements using cadmium ratios and threshold foil detectors, and the determination of excess sample pressures generated during irradiation.

**14084.** Grabner, L. H., Hosler, W. R., Frederikse, H. P. R., **Some optical and electrical properties of undoped and Sr-doped  $\text{LaCrO}_3$** , *Proc. 14th Symp. on Engineering Aspects of Magnetohydrodynamics*, Tullahoma, Tenn., Apr. 8-10, 1974, pp. IV.4.1-IV.4.3 (1974).

Key words: diffuse reflectivity;  $\text{LaCrO}_3$ ; photoconductivity; photoexcitation; photoluminescence; transport data.

Transport data and optical data (photoluminescence, photoexcitation, diffuse reflectivity and photoconductivity) are presented for undoped, and Sr and Ca doped  $\text{LaCrO}_3$ . We conclude that  $\text{LaCrO}_3$  is a wide band-gap semiconductor ( $\sim 7$  eV) in which an oxygen deficiency of the complex  $\text{Cr}^{3+}$  octahedrally coordinated with  $6\text{O}^{2-}$  gives rise to a donor with an activation energy of about 0.5 eV. This oxygen deficiency can be induced as a charge compensation mechanism when  $\text{LaCrO}_3$  is doped with either Sr or Ca.

**14085.** Rook, H. L., Lutz, G. J., LaFleur, P. D., **The use of a high efficiency mass separator in activation analysis**, (Proc. Int. Conf. on Modern Trends in Activation Analysis, Saclay, France, Oct. 1972), *J. Radioanal. Chem.* **15**, 557-565 (1973).

Key words: activation analysis; cadmium; lead; mass separator.

The application of high yield mass separators to problems in activation analysis is discussed. The identification of separation parameters including separator yields, memory, resolution and overlap, and sputtering are considered. The use of the mass separator in determining lead by photon activation analysis is described.

**14086.** Mauer, F. A., Hubbard, C. R., Hahn, T. A., **Anisotropic thermal expansion of  $\alpha\text{-Pb}(\text{N}_3)_2$** , *J. Chem. Phys.* **60**, No. 4, 1341-1344 (Feb. 15, 1974).

Key words: lead azide; thermal expansion.

The anisotropic expansion coefficients of orthorhombic  $\alpha\text{-Pb}(\text{N}_3)_2$  in the temperature range 102-423 K were determined by a single crystal x-ray method. The cell parameters and rms deviations at 298.2 K are  $a = 11.33344[17]$ ,  $b = 16.28277[37]$ , and  $c = 6.64058[10]$  Å. The linear expansion coefficients change gradually from  $\alpha_a = 5.7 \times 10^{-5}$ ,  $\alpha_b = 0.3 \times 10^{-5}$ , and  $\alpha_c = 1.4 \times 10^{-5}$   $\text{K}^{-1}$  at 112, to  $\alpha_a = 8 \times 10^{-5}$ ,  $\alpha_b = 0.4 \times 10^{-5}$ , and  $\alpha_c = 2.0 \times$

$10^{-5}$   $\text{K}^{-1}$  at 412 K. The largest expansion is in the  $a$  direction, which is perpendicular to sheets of azide ions separated by lead atoms.

**14087.** Mulholland, G. W., Rehr, J. J., **Coexistence curve properties of Mermin's decorated lattice gas**, *J. Chem. Phys.* **60**, No. 4, 1297-1306 (Feb. 15, 1974).

Key words: coexistence curve; critical azeotrope; critical double point; decorated lattice gas; maxithermal point; renormalization.

Mermin's decorated lattice gas, noteworthy for its singular coexistence curve diameter and previously studied in connection with the breakdown of the law of rectilinear diameters, is shown to display in addition a rich variety of coexistence curve shapes and kinds of critical behavior as the interaction parameters of the model are varied. For an attractive decoration interaction, the coexistence curve of the model resembles, and can closely approximate, the liquid-vapor coexistence curve of real fluids. For a sufficiently repulsive decoration interaction, however, the model is shown to possess (at fixed temperature) three transitions to increasingly dense phases. These coexistence curves may feature peculiar shapes, such as necks and cusps, and they can appear inverted near the critical point; these curves terminate at either a critical point or at a maxithermal point (an analog of an azeotropic point). For discrete values of the interaction parameters, the model possesses a critical double point (the coalescence of two critical points) or a *cuspidal* critical point (critical azeotropy), in which cases the critical exponents become renormalized. Qualitatively these results are found to be independent of lattice structure and spatial dimensionality  $d \geq 2$ , and representative coexistence curves are plotted for the simple cubic lattice. Possible applications of these results are mentioned.

**14088.** Abrams, M. D., Lindamood, G. E., Pyke, T. N., Jr., **Measuring and modelling man-computer interaction**, *Proc. 1st Annual SIGME Symp. on Measurement and Evaluation*, Palo Alto, Calif., Feb. 26-28, 1973, pp. 136-142 (Feb. 1973).

Key words: dialogue; interaction; man-computer; measure; model; monitor.

The Dialogue Monitor has been developed as a tool for the measurement of computer service. The objectives of such measurement are defined. A set of models and measures is developed. Operation of the Dialogue Monitor and analysis of the data obtained are briefly discussed.

**14089.** Beatty, R. W., **Methods for automatically measuring network parameters**, *Microwave J.* **17**, No. 4, 45-49, 63 (Apr. 1974).

Key words: automatic measurements; automatic network analyzer; complex reflection coefficients; complex transmission coefficients; computer controlled measurement systems; computer-operated transmission measurements; envelope delay; group delay; network parameters.

A survey is presented of techniques, from 1934 to the present time, used in the automatic measurement of network parameters. Some of the computer-controlled measurement systems developed in the U.S.A. since 1968 are described. The direction that future developments may take is forecast. Numerous references are given.

**14090.** Newell, A. C., Crawford, M. L., **Planar near-field measurements on high performance array antennas**, *Proc. 23d U.S. Air Force Antenna Symp.*, Urbana, Ill., Oct. 10-12, 1973, preprint 66 pages (Wright-Patterson Air Force Base, Dayton, Ohio, Oct. 1973).

Key words: antennas; near-field measurements; phased arrays.



The results of measurements are described which apply the planar near-field measurement technique to phased array antennas. Fast and efficient tests are used to determine the required scan area and data point spacing. The use of these tests can reduce the amount of data required for some antennas without seriously increasing the errors in computed results.

Measurements were made at different distances from the antennas, with the probe transmitting and receiving, and for both sum and monopulse difference patterns. Comparisons between the far-field patterns computed from the near-field data and those measured on far-field ranges are presented.

**14091.** Lyndon, R. C., Newman, M., **Commutators as products of squares**, *Proc. Amer. Math. Soc.* **39**, No. 2, 267-272 (July 1973).

Key words: commutators; products of squares; squares, products.

It is shown that if  $G$  is the free group of rank 2 freely generated by  $x$  and  $y$ , then  $xyx^{-1}y^{-1}$  is never the product of two squares in  $G$ , although it is always the product of three squares in  $G$ . It is also shown that if  $G$  is the free group of rank  $n$  freely generated by  $x_1, x_2, \dots, x_n$ , then  $x_1^2x_2^2\cdots x_n^2$  is never the product of fewer than  $n$  squares in  $G$ .

**14092.** Wachtman, J. B., Jr., Schneider, S. J., **Measurements and standards for high temperature materials in energy conversion and clean fuel production**, *Stand. News* **1**, No. 8, 16-23 (Aug. 1973).

Key words: clean fuel; coal; energy; gas; gas turbine; MHD; slag.

The serious energy situation in the United States requires greatly increased use of fossil fuel over the next thirty years despite the projected growth of nuclear power generating capacity. More efficient generation of electric power from coal and very large production of clean fuel from coal are urgently needed. Both require high temperatures and highly reactive chemical conditions.

The severe environments existing in high temperature gas turbines, MHD power generators, and coal gasifiers are briefly summarized. Data and test methods needed for process optimization, engineering design of hardware, and reliability assurance are analyzed. Early results are presented on slag characterization and on reaction of slag components with refractories. Typical data on viscosity of slag and on electrical conductivity of slag and alumina insulating material are given. A procedure to insure required lifetime under service stress is described. The implications of the present work for practical test methods for mechanical lifetime assurance, corrosion resistance, electrical conductivity measurements, viscosity measurements, and wear are assessed.

**14093.** Kusuda, T., **Effectiveness method for predicting the performance of finned tube coils**, *ASHRAE Symp. Bull.*, pp. 5-14 (1970).

Key words: air conditioning; cooling and dehumidifying capacities; effectiveness; finned tube coil; heat transfer; refrigeration.

In 1960 the author proposed using the effectiveness method for predicting the heat and mass transfer performance of chilled water coils. This method is reviewed and elaborated. Comparisons of predicted chilled water dehumidifying coil capacities using this method with observed experimental values given by Prof. Trapanese of Italy were made. The comparisons show that the effectiveness method is accurate if the parameters employed in the effectiveness equation are properly evaluated.

The effectiveness method also appears to be a powerful con-

cept for predicting the performance of finned tube coils at conditions other than those originally selected for design purposes.

**14094.** Burns, G. W., Hurst, W. S., **Some studies on the behavior of W-Re thermocouple materials at high temperatures**, *NASA CR-72884*, 42 pages (National Aeronautics and Space Administration, Washington, D.C., Feb. 1972). (Available as N 7220401 from the National Technical Information Service, Springfield, Va. 22151).

Key words: beryllium oxide; drift; microstructure; thermal emf-temperature; thermocouples; tungsten-rhenium alloys.

Bare 0.25 mm diameter W-Re alloy thermoelements (W, W-3% Re, W-5% Re and W-25% Re) and BeO-insulated W-3% Re and W-25% Re thermoelements have been examined for metallurgical, chemical and thermal emf changes after testing for periods up to 1000 hours at temperatures principally in the range 2000 to 2400 K. Environments for the tests consisted of high purity argon, hydrogen, helium or nitrogen gases. Commercially obtained bare-wire thermoelements typically exhibited a shift in their emf-temperature relationship upon initial exposure. The shift was completed by thermally aging the W-3% Re thermoelement for 1 hour and the W-25% Re thermoelement for 2 minutes at 2400 K in argon or hydrogen. Aged thermoelements experienced no appreciable drift with subsequent exposure at 2400 K in the gaseous environments. The chemically "doped" W-3% Re thermoelement retained a small-grained structure for exposure in excess of 50 hours at 2400 K. BeO-insulated thermoelement assemblies showed varied behavior that depended upon the method of exposure. However, when the assemblies were heated in a furnace, no serious material incompatibility problems were found if the materials were given prior thermal treatments. Thermocouples, assembled from aged W-3% Re and W-25% Re thermoelements and degassed sintered BeO insulators, exhibited a drift of only 2 to 3 K during exposure in argon at 2070 K for 1029 hours.

**14095.** Ehrlich, M., **Dosimetry performance tests**, (Proc. Panel on National and International Radiation Dose Intercomparisons, Vienna, Austria, Dec. 13-17, 1971), Paper IAEA-PL-479/8 in *National and International Radiation Dose Comparisons*, pp. 41-57 (International Atomic Energy Agency, Vienna, Austria, 1973).

Key words: choice of dosimeters; electrons; ferrous sulfate dosimeters; medical applications; performance criteria; personnel monitoring; photographic film; photons; radiation measurements; test patterns.

This report presents a discussion of the need for critical studies of radiation measurement techniques and routine measurement performance. The aim of such studies is to improve practical measurement performance by periodic testing and by the distribution of the knowledge gained by the participants in such tests. Besides general consideration, such items as test pattern, choice of dosimeters and examples from tests are discussed.

**14096.** Kropschot, R. H., **Helium heat transfer**, *Proc. Application of Superconducting Cable in Electrical Engineering and High Energy Physics, Titisee, Germany, Oct. 9-13, 1972*, pp. D1-D32 (Gesellschaft fuer Kernforschung, Karlsruhe, Germany, 1973).

Key words: cryogenics; heat transfer; helium; refrigeration; thermodynamic properties.

Design of an optimum superconducting device such as a magnet, cavity, generator, motor, transmission line or electronic device requires careful consideration of heat transfer. Any transient or oscillatory electrical behavior will cause heat generation which must be removed in order to permit continuous operation. Helium is the only cooling medium for most applications



and as system size, cost and complexity increase it may not be practical to immerse the conductor in a container of helium and depend upon pool boiling, commonplace in small laboratory magnets. The purpose of this paper is to present the state of the art of reliable data on helium properties and helium heat transfer necessary for serious engineering studies of superconducting systems.

- 14097.** Kessler, K. G., **The role of resonance interactions in some molecular far-infrared laser systems**, *Comments At. Mol. Phys.* **11**, No. 2, Part D, 67-72 (June-July 1970).

Key words: Coriolis interactions; infrared lasers; molecular lasers.

An analysis of the HCN laser system is presented and generalized to explain the operating mechanism for molecular lasers systems in general.

- 14098.** Kanda, M., Adams, J. W., **Amplitude statistics of electromagnetic noise in coal mines**, *Proc. Thru-the-Earth Electromagnetics Workshop, Colorado School of Mines, Golden, Colo., Aug. 15-17, 1973*, pp. 156-160 (1973).

Key words: amplitude probability distributions; electromagnetic compatibility; electromagnetic interference in coal mines; field strength measurement.

A system for measuring amplitude probability distributions (APD's) of electromagnetic noise in coal mines is described and typical APD's from an underground coal mine are presented. The APD is a basic statistic required for the design and analysis of communication systems, especially those intended for use in noisy environments, and where neither overdesign nor underdesign is acceptable. The rms and average field strengths are obtained by integration of the APD, and examples are shown at several frequencies. All field strength levels are given in absolute units. Selected frequencies cover the range from 10 kHz to 32 MHz.

- 14099.** Olver, F. W. J., **Error bounds for stationary phase approximations**, *SIAM J. Math. Anal.* **5**, No. 1, 19-29 (Feb. 1974).

Key words: asymptotic approximations; error analysis; generalized integrals; special functions; stationary phase; Watson's lemma.

An error theory is constructed for the method of stationary phase for integrals of the form

$$I(x) = \int_a^b e^{ixp(t)} q(t) dt.$$

Here  $x$  is a large real parameter, the function  $p(t)$  is real, and neither  $p(t)$  nor  $q(t)$  need be analytic in  $t$ . For both finite and infinite ranges of integration, explicit expressions are derived for the truncation errors associated with the asymptotic expansion of  $I(x)$ . The use of these explicit expressions for the computation of realistic error bounds is illustrated by means of an example.

- 14100.** Hagen, L., **Report of The National Bureau of Standards 1972/73, for Reports of Observatories**, *Bull. Amer. Astronom. Soc.* **6**, No. 1, 140-144 (1974).

Key words: atomic energy levels; atomic line shapes; atomic spectra; atomic transition probabilities; bands; molecular; energy levels, atomic; line shapes, atomic; molecular bands; molecular spectra; rotational constants.

Research at the National Bureau of Standards in spectroscopy pertinent to astronomy is summarized. Publications on atomic spectra, atomic transition probabilities and line broadening, and molecular spectra are referenced and work in progress is discussed.

- 14101.** Crenshaw, R., Thomas, C., Ramsey, R., Morgenroth, D., **An approach to performance specifications for public buildings**, (Proc. Int. Conf. on Planning and Design of Tall Buildings, Lehigh Univ., Bethlehem, Pa., Aug. 21-26, 1972), Paper in *Tall Building System and Concepts*, **Ia**, 797-806 (1972).

Key words: office buildings; performance criteria; systems, building.

A progress report after one year on the use of *The PBS Performance Specification for Office Buildings* for the construction of three Social Security Payment Centers. The report is mainly concerned with the shift in responsibility for the architect, industry, research and management.

- 14102.** Greene, W. E., Jr., **Stochastic models and live load surveys**, (Proc. Int. Conf. on Planning and Design of Tall Buildings, Lehigh Univ., Bethlehem, Pa., Aug. 21-26, 1972), Paper in *Tall Building System and Concepts*, **Ib**, 35-58 (1972).

Key words: computer simulation; live and fire loads; occupancy; stochastic predictive models; survey; techniques.

Design fire loads and live loads for office buildings are based on data collected over 30 years ago. Maximum cost efficiency in gathering this loads data requires the use of stochastic models. Explanatory models based on room characteristics such as room use, occupancy type, age of occupancy, etc. are used to determine (explain) room loads for the rooms not surveyed. Only about 10,000 rooms will be surveyed from about 100 office buildings which will serve to provide information for estimating parameters for the predictive loads models (sustained, maximum sustained, extraordinary). The explanatory models will provide the remaining room loads. The topology of these 100 buildings having been previously programmed and stored in the computer, all rooms of the building population will be loaded through mathematical simulation. A pilot study, using a limited amount of previously collected data has been initiated to verify these models as much as possible, this will be followed by a reduced survey of about 25 buildings to further refine the models before the major survey of approximately 75 buildings will be conducted.

- 14103.** Wright, R. N., **Survey of fire and live loads**, (Proc. Int. Conf. on Planning and Design of Tall Buildings, Lehigh Univ., Bethlehem, Pa., Aug. 21-26, 1972), Paper in *Tall Building System and Concepts*, **Ib**, 128-130 (1972).

Key words: buildings; design; fire loads; fire rating; floor loadings; live loads; stochastic models.

This discussion, presented at the session on gravity loads and temperature effects of the ASCE-IABSE Conference on Tall Buildings, outlines a program of survey of fire and live loads which the National Bureau of Standards is beginning under the auspices of the Building Research Advisory Board and the sponsorship of the Public Building Service of the General Services Administration. Its objectives are to improve the technical bases for criteria for fire ratings of buildings and for floor loadings used in building design. The surveying will employ stochastic models for representation of loadings developed at NBS. It will provide a data base for immediate improvements in building standards for fire resistance and design live loads. The information surveyed also will provide an information basis for long-range scientific studies to develop new design concepts for control of building fires and new criteria for mitigation of fire effects. The live loads information will allow theoretical studies of design load configurations leading to more consistent probabilistic formulations of combinations of loadings from the building's own weight, the effects of occupancy, effects of wind, effects of earthquake, etc.



**14104.** Dalglish, W. A., Marshall, R. D., **Research review—North and South America**, (Proc. Int. Conf. on Planning and Design of Tall Buildings, Lehigh Univ., Bethlehem, Pa., Aug. 21-26, 1972), Paper in *Tall Building System and Concepts*, **Ib**, 383-398 (1972).

Key words: climatological data; meteorology; tall buildings; wind effects; wind loads; wind tunnel.

The current status of research in North and South America relevant to the prediction of tall building behavior in response to wind is reviewed under four main headings: Meteorological research—wind structure and climate; Full-scale investigations of wind action on tall buildings; Development of wind tunnel techniques for building aerodynamics; Simplified theoretical models of wind effects on tall buildings.

**14105.** Somes, N. F., **Progressive collapse risk**, (Proc. Int. Conf. on Planning and Design of Tall Buildings, Lehigh Univ., Bethlehem, Pa., Aug. 21-26, 1972), Paper in *Tall Building System and Concepts*, **Ib**, 727 (1972).

Key words: accident occurrence; building; gas explosion; hazards; progressive collapse; tall buildings.

The National Bureau of Standards is undertaking an extensive study on behalf of the U.S. Department of Housing and Urban Development. The objectives are to determine the nature and frequency of occurrence of the various forms of extreme local loads on high rise buildings and to develop criteria necessary to reduce the risk of progressive collapse to an acceptable level.

**14106.** Yokel, F. Y., Wright, R. N., **Summary report—Technical Committee No. 26, Limit states design**, (Proc. Int. Conf. on Planning and Design of Tall Buildings, Lehigh Univ., Bethlehem, Pa., Aug. 21-26, 1972), Paper in *Tall Building System and Concepts*, **III**, 949-953 (1972).

Key words: deterioration; failure; limit states design; mode of failure; reliability; structural failures.

A limit state has been defined as "a particular state, in which a structure ceases to fulfill the function or to satisfy the condition for which it is designed" (1). By this definition a limit state is a mode of failure, which includes failure to perform a specific function or to provide a desired attribute. The goal of limit states design as presently defined is to give explicit consideration to all failure modes and to assure a suitably low probability that the structure or any of its components reach a limit state in service.

The state of the art reports presented in behalf of Committee 26 identify limit states of reinforced concrete structures and survey our knowledge with respect to the application of limit states design. In this paper the state of the art reports are summarized and some new definitions are suggested for consideration.

**14107.** Dikkers, R. D., **Summary report—Technical Committee No. 27, Masonry structures**, (Proc. Int. Conf. on Planning and Design of Tall Buildings, Lehigh Univ., Bethlehem, Pa., Aug. 21-26, 1972), Paper in *Tall Building System and Concepts*, **III**, 1103-1114 (1972).

Key words: bricks; building codes; buildings; concrete blocks; masonry; research; reinforced masonry; structural engineering; walls.

The re-emergence of masonry as a modern and viable structural material during the past decade is described. Buildings have been constructed up to a height of 206 ft (63 m) utilizing 10-in (254 mm) thick loadbearing masonry walls. Extensive research programs have been recently conducted but high priority should be given to additional investigations of reinforced masonry. Various needs in masonry standards and codes of practice are also identified. The use of prefabricated and prestressed masonry should continue to increase in the future.

**14108.** Mandel, J., **The evaluation of referee methods in clinical chemistry**, *Med. Instrum.* **8**, No. 1, 26-29 (Jan.-Feb. 1974).

Key words: accuracy; calcium in serum; clinical testing; interlaboratory comparisons; precision.

The importance of clinical testing to health demands that both precision and accuracy be achieved. Proficiency testing has shown that generally this is not the case. The next task is to study some individual clinical methods in depth to provide the profession with well developed referee methods. An interlaboratory study of a test method involves five elements: the protocol, samples, laboratories, statistical design, and analysis of the data. These elements are discussed and illustrated in terms of determining calcium in serum by atomic absorption spectrometry, using isotope dilution mass spectrometry as a standard of accuracy. This study, consisting of five "exercises," shows that only through constant vigilance and an attitude of real concern can acceptable levels of precision and accuracy be achieved.

**14109.** Roberts, R. W., **Freedom and social responsibilities**, *IEEE Spectrum* **11**, No. 4, 59-60 (Apr. 1974).

Key words: computer privacy; freedom of information; information; public information.

The guiding principle of the Freedom of Information Act is promotion of the public interest. Effective use of technical information requires more than "freedom," if by freedom one means merely unrestricted access. It requires a sense of responsibility and an activist approach toward evaluation and distribution to assure adequate dissemination of correct information. This is our approach at NBS.

**14110.** McClendon, L. T., LaFleur, P. D., **Determination of rare earths in standard reference material glass using neutron activation analysis and reversed-phase chromatography**, *J. Radioanal. Chem.* **16**, 123-126 (1973).

Key words: di(2-ethylhexyl) orthophosphoric acid, Corvic; NBS Standard Reference Material 480; neutron activation analysis; rare earths; reversed-phase chromatography.

Recently, the interest in quantitative determination of rare earth elements has grown considerably, especially in connection with the space programs. There has also been a need for quantitative methods for rare earth element determination in different matrices at the National Bureau of Standards. We have therefore applied some of our earlier qualitative investigations with di(2-ethylhexyl) orthophosphoric acid (HDEHP) to separations of these elements for their subsequent quantitative determination. The rare earth elements in NBS Standard Reference Material 480, Trace Elements in Glass, a sodium glass to which 61 trace elements, including the thirteen naturally occurring rare earths, were added, have been determined by neutron activation analysis with a chemical separation using a column (11 cm × 40 cm) of "Corvic" powder [poly(vinyl chloride-vinyl acetate)] loaded with HDEHP and operated at a constant temperature. Since our earlier solvent extraction studies with HDEHP had shown perchloric acid to be the most favorable of three acids (HCl, HNO<sub>3</sub>, HClO<sub>4</sub>) for rare earth separation, we established the best operating conditions (e.g., time, flow, acid concentration, etc.) using this acid.

**14111.** Wait, D. F., Beatty, R. W., **The 1973 International Microwave Symposium**, *IEEE Trans. Microwave Theory Tech.* **MTT-21**, No. 12, 747-751 (Dec. 1973).

Key words: exhibits; microwave; symposium.

The 1973 IEEE G-MTT International Microwave Symposium was held June 4-6, 1973, in Boulder, Colo. The theme was "Microwave Applications in the 70's."



**14112.** Risley, E. W., Jr., **Discontinuity capacitance of a coaxial line terminated in a circular waveguide. Part II—Lower bound solution**, *IEEE Trans. Microwave Theory Tech.* MTT-21, No. 8, 564-566 (Aug. 1973).

Key words: coaxial line; lower bound; open circuit termination.

This calculation provides a lower bound (complementing the upper bound solution given earlier) to the discontinuity capacitance of a coaxial line terminated in a circular waveguide. A 50- $\Omega$  0.9525-cm (3/4-in) open-circuited coaxial termination with a solid center conductor was fabricated with center- and outer-conductor diameters of  $0.82723 \pm 0.00005$  and  $1.90487 \pm 0.00005$  cm (1 cm = 0.393703 in), respectively. The measured value of capacitance of this termination at 1000 Hz was  $216.4 \pm 1.0$  fF, as compared with the calculated lower bound of 215.0 fF. (The upper bound for this case was 217.7 fF.)

**14113.** Maryott, A. A., Malmberg, M. S., Gillen, K. T., **Effective collision numbers for angular momentum relaxation from nuclear relaxation studies of simple liquids**, *Chem. Phys. Lett.* 25, No. 2, 169-174 (Mar. 15, 1974).

Key words: angular momentum relaxation; collision numbers; liquids; NMR relaxation; rotational diffusion; spin-rotation.

Angular momentum correlation times,  $\tau_J$ , derived from nuclear relaxation studies of a number of liquids composed of small molecules of high symmetry are compared with hard sphere and cell model collision rates. Either model leads to the conclusion that collision efficiency is high (collision number of 1 to 2) and provides a useful and simple relationship for predicting  $\tau_J$  semiquantitatively over the liquid range.

**14114.** Maximon, L. C., O'Connell, J. S., **Sum rules for forward elastic photon scattering**, *Physics Letters* 48B, No. 5, 399-402 (Mar. 4, 1974).

Key words: Compton scattering; dispersion relations; photon; proton; scattering; sum rules.

Relations between integrals over forward elastic photon scattering amplitudes, forward elastic cross sections and total cross sections are derived from dispersion relations. A new photon-proton interaction sum rule is derived and evaluated.

**14115.** Lutz, G. J., **Determination of lead in paint with fast neutrons from a californium-252 source**, *Anal. Chem.* 46, No. 4, 618-620 (Apr. 1974).

Key words: activation analysis; californium-252; lead; neutron irradiation; paint.

Large amounts of lead in the paint on walls in dwellings is potentially hazardous to children in certain susceptible age groups who may ingest it. Most analytical methods for screening suspect homes require lengthy dissolution or other chemical procedures. Activation analysis with unmoderated neutrons from a  $^{252}\text{Cf}$  source inducing the nuclear reaction  $^{204}\text{Pb}(n,n')^{204m}\text{Pb}$  followed by gamma spectrometry with a Ge(Li) detector is shown to be a convenient, reliable and potentially rapid nondestructive method for this determination. The lower limit of determination in a 1.5 gram sample of paint with a 600  $\mu\text{g}$  source of  $^{252}\text{Cf}$  is of the order of one percent lead.

**14116.** Spiegel, V., **The effective half-life of californium-252**, *Nucl. Sci. Eng. Tech. Note* 53, No. 3, 326 (Mar. 1974).

Key words: activation analysis; californium-252; manganese activity; neutron irradiation.

The effective half-life of  $^{252}\text{Cf}$  has been determined as  $2.638 \pm 0.007$  yr. The method utilized the ratio of the manganese activity induced in a manganous-sulfate bath by a  $^{252}\text{Cf}$  spontaneous-fis-

sion neutron source and the National Bureau of Standards photoneutron source to measure the change in emission rate of the  $^{252}\text{Cf}$  source over a period of 1.77 half-lives. The data were corrected for the activity of radium (1622-yr half-life) in the photoneutron source ( $-0.2\%$ ) and for the competing neutron production from  $^{250}\text{Cf}$ .

**14117.** Treu, S., Pyke, T. N., Jr., **Project-oriented collaboration via a computer network**, *Proc. Computer Science Conference, Columbus, Ohio, Feb. 1973*, p. 27 (1973).

Key words: computer network; interpersonal communications; task group collaboration.

Given a commitment to collaborate on a particular project, but hampered by geographical separation, a telecommunications triangle was established within the context of the ARPA Network. The triangle consisted of NBS, Pitt and ECOM. Several staff/faculty members at the first two institutions employed facilities of the Network Information Center (SRI) in order to formulate plans, exchange ideas, and produce specific results in support of a project at ECOM. That project involved interactive graphics for computer-aided design and engineering. ECOM personnel were able to "observe" and supply feedback when appropriate. A set of written ground rules for participation and data collection sheets for recording individual experiences were designed in advance. Results of this project-oriented collaboration have been analyzed in terms of feasibility, productivity, and required network capabilities.

**14118.** McLaughlin, W. L., Holm, N. W., **Physical characteristics of ionizing radiation**, Chapter 1 in *Manual on Radiation Sterilization of Medical and Biological Materials*, *Tech. Reports Series No. 149*, pp. 5-12 (International Atomic Energy Agency, Vienna, Austria, 1973).

Key words: dosimetry; electrons; gamma rays; ionizing radiation; microdosimetry; radiation physics; radiation sterilization; radiobiology; x rays.

An important step in developing the background for the radiation sterilization process is to review the physics and chemistry of radiation interactions in matter and the quantities that are used for monitoring radiation energy depositions. From this basis we can go on in subsequent chapters to the practical considerations of how efficiently the most radiation-resistant living organisms (fungi, bacteria, viruses, etc.) can be inactivated without causing excessive damage to the host material.

**14119.** Blanc, R., **Minicomputer trends and applications—1973**, *Computer* 6, No. 6, 28-29 (June 1973).

Key words: minicomputer applications; minicomputer maintenance; minicomputer peripherals; minicomputer software.

The present trends in the growth and utilization of minicomputers as presented and discussed at a recent Symposium cosponsored by NBS are reviewed. In addition, problems are identified in the areas of minicomputer software, peripherals, and maintenance.

**14120.** Jan, G., Mendlowitz, H., **Optical imaging with frequency-dependent spectral-density functions**, *J. Opt. Soc. Amer.* 61, No. 7, 865-869 (July 1971).

Key words: coherence; image formation; modulation transfer; optical transfer function.

In this investigation, the quasimonochromatic condition is not assumed, and the spectral-density function of the radiation depends on frequency as well as on positions. We discuss various models for the impulse-response function of the optical system, and examine the results in temporal-frequency space. We approximate the integration by employing the method of steepest



descent. An explicit relation of the mutual coherence function and the spectral-density function of the source is established with some correction factors that differ from the results of the quasimonochromatic approximation.

- 14121.** Abrams, M. D., Rosenthal, R., **On the passing of MOBIDIC-B**, *Computer 6*, No. 3, 10-18 (Mar. 1973).

Key words: computer; MOBIDIC-B; teleprocessing system.

The history, design, hardware configuration, instruction set and operating system of the MOBIDIC-B used in the National Bureau of Standards (NBS) computer research facility is described using conventional methods and Bell and Newell's PMS and ISP notations. As modified at NBS, MOBIDIC-B is the nucleus of an experimental remote access computer system, with variable partition multiprogramming capability, that supports conversational terminal usage.

- 14122.** Pyke, T. N., Jr., Blanc, R. P., **Computer networking technology—A state of the art review**, *Computer 6*, No. 6, 13-19 (Aug. 1973).

Key words: computer-communications; computer network architecture; computer networks.

Computer networking technology as represented by existing and planned computer networks is reviewed. Functional capabilities of alternative approaches to networking are considered particularly in terms of terminal and host computer system interfaces. Commonalities and differences in network architecture are identified. The limitations of existing network technology are discussed to clearly identify current problems and to indicate areas where further research and development is needed.

- 14123.** Brower, W. S., Parker, H. S., Roth, R. S., **Reexamination of synthetic parkerite and shandite**, *Amer. Mineral.* **59**, 296-301 (1974).

Key words: chalcogenides; parkerite; shandite; subsulfides.

A reinvestigation of synthetic parkerite,  $\text{Ni}_3\text{Bi}_2\text{S}_2$ , has demonstrated that the unit cell is 4 times the volume of that previously reported (Michener and Peacock, 1943). It has monoclinic symmetry, most probable space group  $C2/m$  with  $a=11.066$ ,  $b=8.085$ ,  $c=7.965$  Å,  $\beta=134.0^\circ$ . The larger cell was confirmed by single crystal x-ray diffraction data, but can be deduced from the presence of extra lines in the powder pattern of a specimen which has been annealed after grinding. This same technique revealed the rhombohedral distortion of shandite,  $\text{Ni}_3\text{Pb}_2\text{S}_2$ , space group  $R\bar{3}m$ , previously thought to be dimensionally cubic. The unit cell of shandite was found to be  $a=5.591$ ,  $c=13.579$  Å. The Sn analogue of shandite,  $\text{Ni}_3\text{Sn}_2\text{S}_2$ , reported for the first time, is hexagonal with  $a=5.465$ ,  $c=13.196$  Å. We were unable to synthesize any Mn, Fe, Co, or Cu analogs of the parkerite-shandite series.

- 14124.** Bass, A. M., Laufer, A. H., **Extinction coefficients of azomethane and dimethyl mercury in the near ultra-violet**, *J. Photochem. Short Communication 2*, 465-470 (1973/74).

Key words: absorption spectrum; azomethane; dimethyl mercury; extinction coefficient; ultraviolet.

The absorption spectra and extinction coefficients of azomethane and dimethyl mercury have been measured between 170-360 nm. In each case the absorption consists of an intense broad band upon which is superimposed a vibrational sequence of a single frequency. For azomethane the vibrational spacing is about  $470\text{ cm}^{-1}$ ; for dimethyl mercury it is about  $347\text{ cm}^{-1}$ . The vibrational frequencies of the upper states have been tentatively assigned.

- 14125.** Unassigned.

- 14126.** Lutz, G. J., **The analysis of biological and environmental samples for lead by photon activation**, *J. Radioanal. Chem.* **19**, 239-244 (1974).

Key words: biological samples; environmental samples; lead; photon activation analysis.

The photonuclear reaction  $^{204}\text{Pb}(\gamma, n)^{203}\text{Pb}$  is used for the determination of lead in biological and environmental samples. Precision and accuracy were determined to be adequate by analyzing some samples which have been assayed for lead by other methods. With a rigorous post-irradiation separation, the limit of detection is of the order of tens of nanograms.

- 14127.** Hurlock, S. C., Lafferty, W. J., Rao, K. N., **Analysis of the  $\nu_3$  band of  $^{14}\text{N}^{16}\text{O}_2$** , *J. Mol. Spectrosc.* **50**, 246-256 (1974).

Key words: air pollutant; fundamental vibrational band; high-resolution; molecular constants; spin-splittings; vibration-rotation.

The rotational structure of the  $\nu_3$  fundamental of  $^{14}\text{N}^{16}\text{O}_2$  has been recorded by employing a vacuum grating infrared spectrograph. The analysis has led to the assignment of over 500  $R$ - and  $P$ -branch transitions in the spectral region  $1650\text{--}1562\text{ cm}^{-1}$ . Molecular constants for the upper state, 001, have been presented. No  $Q$ -branch transitions were used in the evaluation of these constants. The presently obtained  $\alpha_3^A=0.22517\text{ cm}^{-1}$  and the band center  $\nu_0=1616.846\text{ cm}^{-1}$  differ significantly from previous determinations. Spin splitting was observed but no information was extracted about upper state spin splitting parameters.

- 14128.** Kearsley, E. A., **A test sample to standardize measurements of normal stress**, *Rheol. Acta* **12**, No. 4, 546-549 (1973).

Key words: molecular weight distribution; normal stress; polystyrene solutions; standard sample; streaming birefringence.

This paper is an account of the design of a test sample of polystyrene solution which will be distributed to research laboratories interested in participating in a comparison of techniques of measurement of normal stresses through a common sample. Questions of concentration, molecular weight distribution and solvent properties are considered.

- 14129.** Carroll, J. J., Melmed, A. J., **Optical constants of titanium**, *J. Opt. Soc. Amer. Letters to Editor* **64**, No. 4, 514-515 (Apr. 1974).

Key words: ellipsometry; optical constants; titanium.

Optical constants of (0001) titanium at  $\lambda=5461$  Å were measured ellipsometrically under a variety of conditions. The results are compared to the appropriate literature values.

- 14130.** Huebner, R. H., Celotta, R. J., Mielczarek, S. R., Kuyatt, C. E., **Electron energy loss spectroscopy of acetone vapor**, *J. Chem. Phys.* **59**, No. 10, 5434-5443 (Nov. 15, 1973).

Key words: acetone vapor; electron energy-loss spectroscopy; oscillator strength.

High resolution, inelastic electron scattering data can provide new spectroscopic information on the electronic structure of polyatomic molecules. Features in the acetone energy loss spectrum from 0 to 15 eV obtained for 100 eV incident electrons correspond to vibrational, electronic discrete, and electronic continuum excitations. These data are compared with optical measurements in a wide spectral region extending from the infrared to the vacuum ultraviolet. A comprehensive interpretation of the energy loss spectra is attempted with the use of photochemical and photoelectron data, as well as quantum-chemical calculations in the literature. Three Rydberg series with quantum defects of 1.03, 0.81, and 0.315 join onto bands previously



discussed in terms of transitions to valence orbitals. These series converge to an ionization limit of 9.705 eV in good agreement with previous optical determinations. Dissociative continua underlie the Rydberg region and give rise to a variety of neutral products observed in recent photolysis work. Broad features in the ionization continuum appear to correlate generally with higher ionization potentials observed by photoelectron spectroscopy. Apparent oscillator strengths derived from the energy loss data for the bands at 4.4 and 6.35 eV and for a region (9.7–11.78 eV) of the ionization continuum agree very well with the photoabsorption measurements. Integrated oscillator strengths of 0.46 below 9.7 eV and 3.93 below 15 eV were derived from the electron impact data.

- 14131.** Wakeford, O. S., Robinson, D. E., **Lateralization of tonal stimuli by the cat**, *J. Acoust. Soc. Amer.* **55**, No. 3, 649–652 (Mar. 1974).

Key words: animal audition; cats; animal psychophysics; auditory lateralization; auditory localization; avoidance; binaural hearing; earphones for animals; interaural differences.

The ability of the cat to "lateralize" tonal signals having interaural intensive or interaural temporal disparities was measured. Interaural intensive differences were studied at 0.5, 1.0, and 3.0 kHz. Interaural temporal differences were studied at 0.5, 1.0, 2.0, and 3.0 kHz. Miniature audio transducers were employed to present the stimuli to the animals. The transducers were held in a fixed spatial relation to the auditory canal by means of "pinna inserts" and leather helmets. An avoidance response in a shuttle box was used as the dependent variable. The animals' task involved the detection of a right-left reversal in a gated sequence of tone bursts. The cat appears to be about as sensitive as the human to both interaural intensive and temporal disparities at each of the frequencies studied.

- 14132.** Newman, M., **Diophantine equations in cyclotomic fields**, *J. Reine Angew. Math.* **265**, 84–89 (1974).

Key words: cyclotomic fields; diophantine equations; units.

Let  $K_p$  be the cyclotomic field  $Q(\zeta_p)$ , where  $\zeta_p = \exp(2\pi i/p)$ ,  $Q$  is the field of rationals, and  $p$  is a prime  $> 3$ . The principal result of this paper is that the equation  $\xi = \eta^n - 1$  has no solutions in units  $\xi, \eta$  of  $K_p$  which are not roots of unity, provided that  $n > 2$ . MOS Numbers—10.66, 10.10.

- 14133.** Celotta, R. J., Mielczarek, S. R., Kuyatt, C. E., **Electron energy loss spectrum of ozone**, *Chem. Phys. Lett.* **24**, No. 3, 428–430 (Feb. 1, 1974).

Key words: electron energy-loss; electron excitation; gas scattering; ozone.

Electron energy loss spectra for ozone are presented over the energy loss range 1–30 eV with an incident electron energy of 300 eV. The data are obtained using an electron monochromator-analyzer combination and a static gas cell, and have a resolution of 0.035 eV fwhm.

- 14134.** Celotta, R. J., Bennett, R. A., Hall, J. L., **Laser photodetachment determination of the electron affinities of OH, NH<sub>2</sub>, NH, SO<sub>2</sub>, and S<sub>2</sub>**, *J. Chem. Phys.* **60**, No. 5, 1740–1745 (Mar. 1, 1974).

Key words: electron affinity of NH<sub>2</sub><sup>−</sup>; electron affinity of NH<sub>2</sub><sup>−</sup>; electron affinity of OH<sup>−</sup>; electron affinity of S<sub>2</sub><sup>−</sup>; electron affinity of SO<sub>2</sub><sup>−</sup>; photodetachment.

Using a fixed frequency argon ion laser we have studied the energy spectra of electrons photodetached from OH<sup>−</sup>, NH<sub>2</sub><sup>−</sup>, NH<sup>−</sup>, SO<sub>2</sub><sup>−</sup>, and S<sub>2</sub><sup>−</sup>. We determined the following electron affinities:  $E_A(\text{OH}) = 1.829_{-0.014}^{+0.010}$  eV,  $E_A(\text{NH}_2) = 0.779 \pm 0.037$  eV,  $E_A(\text{NH}) = 0.38 \pm 0.03$  eV,  $E_A(\text{SO}_2) = 1.097 \pm 0.036$  eV, and

$E_A(\text{S}_2) = 1.663 \pm 0.040$  eV. Additionally, the angular distribution anisotropy parameter  $\beta$  was measured for OH<sup>−</sup> and NH<sub>2</sub><sup>−</sup> at 4880 Å, as  $-0.993 \pm 0.040$ , and  $0.027 \pm 0.012$ , respectively, and information about negative ion vibrational constants is presented.

- 14135.** Gadzuk, J. W., **Valence-band Auger-electron spectra for aluminum**, *Phys. Rev. B* **9**, No. 4, 1978–1980 (Feb. 15, 1974).

Key words: attenuation lengths; Auger effect; electron spectroscopy of solids; surfaces.

Recent measurements of the  $L_{23}$  VV Auger spectrum of Al by Powell, have shown that the observed energy distributions do not correspond to the self-convolution of the Al bulk density of states. Attempts to account for this discrepancy in terms of energy-dependent matrix elements and inelastic scattering of the ejected electron are described here.

- 14136.** Dobbyn, R. C., McAlister, A. J., Cuthill, J. R., Erickson, N. E., **Valence band x-ray photoemission and soft x-ray emission studies of Pt**, *Phys. Lett.* **47A**, No. 3, 251–252 (Mar. 25, 1974).

Key words: electronic density of states; Pt; surface cleanliness; valence-band; x-ray photoemission.

The soft x-ray N<sub>6,7</sub> (5d to 4f transition) emission spectrum and the x-ray photoemission spectrum of Pt (the latter under two conditions of surface cleanliness) have been obtained, and are compared with the results of photoemission and band theoretical studies.

- 14137.** Stevens, W. J., Billingsley, F. P. II, **Coupled multiconfigurational self-consistent-field method for atomic dipole polarizabilities. II. Application to the first-row atoms, lithium through neon**, *Phys. Rev. A* **8**, No. 5, 2236–2245 (Nov. 1973).

Key words: atoms; correlation; dipole polarizabilities; excited states; ground state; multiconfiguration.

Static dipole polarizabilities, accurate to within 5 percent are presented for the ground states and some valence excited states of the first-row atoms. The polarizabilities are obtained from multiconfigurational self-consistent-field wave functions, which were computed with the perturbing electric field included directly in the Hamiltonian. The use of the multiconfigurational framework allows any state of both degenerate and non-degenerate atoms to be considered, and also allows for the explicit introduction of electron-correlation effects. Detailed discussions of basis-set selection and the effects of electron correlation are presented along with comparisons with experimental and other theoretical polarizability results.

- 14138.** Hougen, J. T., **Comment on the paper "About the symmetries of the rotation-vibration wavefunction of molecules"**, *J. Mol. Spectrosc.* **50**, 485–486 (1974).

Key words: group theory; methane; rovibronic symmetry species; selection rules; tetrahedral point group.

Qualitative observations are presented concerning the long-standing controversy over the correct use of group-theoretical symmetry operations and symmetry species in the methane molecule. No new mathematical details are introduced; discussion focuses rather on the merits of papers in the existing literature. The observations are presented in response to a comment by Professor J. Moret-Bailly, published simultaneously, in which an opposing point of view is given.

- 14139.** Hellner, C., Keller, R. A., **Flash photolysis of sulfur dioxide**, *J. Air Pollut. Contr. Ass.* **22**, No. 12, 959–963 (Dec. 1972).

Key words: air pollution; flash photolysis; sulfur dioxide; ultraviolet absorption.

The body of information presented in this paper is directed to photochemists and air pollution scientists interested in species



which result from the interaction of  $\text{SO}_2$  and light. When  $\text{SO}_2$  at low pressures is subjected to an intense photolysis flash, the characteristic, very structured  $\text{SO}_2$  absorption spectrum disappears immediately after the flash and is replaced by a continuous absorption. The continuous absorption gradually decays and the normal  $\text{SO}_2$  absorption spectrum returns. The initial absorbance of the continuous absorption is proportional to the square of the  $\text{SO}_2$  pressure and the square of the flash irradiance. From these facts we propose the formation of a metastable dimer of  $\text{SO}_2$  formed by the collision of two excited molecules. Some properties of this dimer are: natural lifetime = 2 sec; energy above separated monomers = 4 kcal; lifetime at atmospheric pressure = 1 sec (quenching coefficients with several foreign gases =  $10^{-20}$   $\text{cm}^3/\text{sec}$  molecule); absorption of ultraviolet light results in photodecomposition of the dimer into monomeric  $\text{SO}_2$ . The long lifetime of this species and its low quenching cross section may make it an important intermediate in photochemical reactions of  $\text{SO}_2$ . The relatively low excitation energy of the metastable species indicates it may also be an intermediate in thermally excited reactions and perhaps an important component of smoke stack effluent.

- 14140.** Kuyatt, C. E., Celotta, R. J., Mielczarek, S. R., **Applications of electron spectroscopy to air pollution measurements**, (Proc. VIII Int. Conf. on Physics of Electronic and Atomic Collisions, Belgrade, Yugoslavia, July 16-21, 1973), Paper in *Proceedings VIII International Conference on Physics of Electronic and Atomic Collisions—Invited Lectures and Progress Reports*, B. C. Cobic and M. V. Kurepa, Eds., pp. 681-701 (Institute of Physics, Belgrade, Yugoslavia, 1974).

Key words: air pollution; electron spectroscopy; energy-loss spectroscopy.

Recent developments in electron spectrometer design have made the application of inelastic electron scattering measurements to gas analysis competitive with other techniques. The energy distribution (energy loss spectrum) of electrons of an initially monoenergetic electron beam after an encounter with a gas target contains the optical absorption spectrum of the gas. This spectrum, by revealing the valence energy states of the gas, is an intrinsic "fingerprint" of the atom or molecule. An instrument has been built to explore the potentialities of this method. Its response is linear with concentration over a very wide range. The instrument is described and its performance as a trace analyzer for air pollution studies discussed.

- 14141.** Brown, W. E., **Physicochemical mechanisms of dental caries**, *J. Dent. Res.* **53**, No. 2, 204-216 (Mar./Apr. 1974).

Key words: caries models; dental caries; phase diagrams; physicochemical mechanism; solubility of enamel.

A review of models for physicochemical mechanisms of dental caries is presented. The existing models belong to three general categories: Equilibrium, steady-state and cyclic. A new interpretation is provided for these models by the application of phase diagram consideration in a generalized four component system,  $\text{Ca}(\text{OH})_2\text{-H}_3\text{PO}_4\text{-HX-H}_2\text{O}$ , in which HX is a bioorganic acid; the role of important factors in caries process is evaluated and advantages and shortcomings of the existing models are discussed. New directions for future research are recommended.

- 14142.** Mitchell, R. A., Woolley, R. M., Chwirut, D. J., **Analysis of composite-reinforced cutouts and cracks**, (Proc. 15th Structures, Structural Dynamics and Materials Conference, Las Vegas, Nev., Apr. 17-19, 1974), AIAA Paper No. 74-377, pp. 1-13 (American Institute of Aeronautics and Astronautics, New York, N.Y., 1974).

Key words: adhesively bonded joints; composite materials; composite-overlay reinforcement; contour plotting; cracks,

reinforcement of; cutouts, reinforcement of; finite element analysis; joints, adhesively bonded; reinforcement, composite overlay; reinforcement, cutouts and cracks.

Finite element computer analyses of the reinforcement of cutouts and cracks in metal sheet, by bonded overlays of composite material, are described. The analyses articulate the separate responses of the sheet, the overlays, and the adhesive. Contour plots of computed stress and strain fields are automatically generated by the computer programs. Strains measured on the surfaces of several reinforced-sheet tensile specimens were, for the most part, in good agreement with strains predicted by the analyses. Significant correlations between certain failure modes observed in the test specimens and the stress distributions given by finite element analysis are apparent. The same analytical approach is currently being used to study weld/bond and fastener/bond joints, and it could be used to study other problems such as hole repair in metal or composite sheet and embedded defects in laminar material.

- 14143.** Okabe, H., **Production of electronically excited species in photodissociation of simple molecules in the vacuum ultraviolet**, (Proc. Advanced Study Institute on Chemical Spectroscopy and Photochemistry in the Vacuum Ultraviolet, NATO, Valmorin, Quebec, Canada, Aug. 1973), Paper in *Chemical Spectroscopy and Photochemistry in the Vacuum Ultraviolet*, C. Sandorfy, P. J. Ausloos, and M. B. Robin, Eds., **8**, Series C, 513-523 (D. Reidel Publishing Co., Dordrecht, Holland, 1974).

Key words: bond energy; fluorescence; photodissociation; predissociation; spin conservation rules; vacuum ultraviolet.

Recent studies of the primary process in the photodissociation of small molecules have been reviewed. The process of producing fluorescing excited species in photodissociation in particular has been studied as a function of incident wavelength. The determination of the threshold wavelength of incident photons required for the production of the excited species provides information on bond dissociation energies and other thermochemical data. The nature of the primary process (i.e., direct dissociation, predissociation, the spin conservation rule, and the configuration of an upper state) has been discussed for some small molecules.

- 14144.** Mihalas, D., Hummer, D. G., **Some observational implications of extended static O-star model atmospheres**, *Astrophys. J.* **189**, L39-L43 (Apr. 1, 1974).

Key words: astrophysics; energy loss; O-stars; radiative transfer; stellar atmospheres.

Some results and observational implications are presented for the first extended spherical non-LTE model atmospheres in hydrostatic and radiative equilibrium. These models all correspond to a star with  $M = 60 M_\odot$ ,  $L = 1.25 \times 10^6 L_\odot$ , and  $R = 24 R_\odot$ , with an effective temperature  $T_{\text{eff}} \approx 39,500$  K and surface gravity  $\log g \approx 3.45$  (spectral type near O6). They are differentiated by the magnitude and radial dependence of a radiation-force multiplier  $\gamma$ , inserted into the equation of hydrostatic equilibrium, to simulate the effect of radiation force on opacity sources (e.g., lines) that have not been included in the calculations. It has been possible to obtain models very close to the limit at which the radiation force balances the gravity. Hydrogen and helium ( $Y = 0.1$ ) constitute the gas; six hydrogen lines are treated explicitly. These models show  $L\alpha$  in emission, the lower Balmer lines in absorption, the Balmer jump in absorption, and both infrared and ultraviolet excesses relative to the visual. Continuum jumps and gradients, Strömgren-system colors, and equivalent widths of  $H\alpha$ ,  $H\beta$ , and  $H\gamma$  are tabulated and discussed briefly.



**14145.** Cunningham, G. W., Meijer, P. H. E., **Exact calculation of the energy and heat capacity for the triangular lattice with three different coupling constants**, *J. Math. Phys.* **15**, No. 1, 55-59 (Jan. 1974).

Key words: anisotropic coupling; elliptic integrals; heat capacity; internal energy; Ising model; triangular lattice.

Calculation of the internal energy and heat capacity of the general anisotropic triangular Ising lattice is derived from the double integral form of the partition function. The principal result is the reduction of the elliptic integrals to a standard form for three arbitrary coupling constants. Both the standard form and the method of reduction are due to Legendre. The method of reduction is one involving two linear transformations. A straightforward reduction of elliptic integrals to standard form could not be used in this application. This is because of the functional dependence of the two linear transformations on the many combinations and permutations of the signs and relative magnitudes of the coupling energies of the lattice. A relatively simple formulation is presented in which the many combinations and permutations previously mentioned are reduced to only two distinct cases. An independent numerical solution was calculated directly from the partition function as a means of verifying the formulation presented in this paper.

**14146.** Day, G. W., Hamilton, C. A., Peterson, R. L., Phelan, R. J., Jr., Mullen, L. O., **Effects of poling conditions on responsivity and uniformity of polarization of PVF<sub>2</sub> pyroelectric detectors**, *Appl. Phys. Lett.* **24**, No. 10, 456-458 (May 15, 1974).

Key words: infrared detectors; PVF<sub>2</sub>; pyroelectric detectors; uniform polarization.

A large number of pyroelectric detectors, fabricated from commercially available PVF<sub>2</sub> and poled under a variety of conditions of voltage, temperature, and time have been evaluated for responsivity and uniformity of polarization in the direction of the poling field. Results show that uniformity of polarization (a requirement for flat frequency response) can be achieved and responsivities as high as 2.9  $\mu\text{A/W}$  can be obtained.

**14147.** Coxon, B., **Studies of carbohydrates by Fourier transform NMR spectroscopy: Structural analysis of glycosyl cyanides**, *Ann. N.Y. Acad. Sci.* **222**, 952-970 (Dec. 31, 1973).

Key words: fluorinated chemical shift reagents; Fourier transform <sup>13</sup>C magnetic resonance spectroscopy; glycosyl cyanides; <sup>13</sup>C-H coupling constants.

Acylated glycosyl cyanides are useful intermediates in the synthesis of C-nucleoside antibiotics, but the preparation of these intermediates from glycosyl halides and heavy metal cyanides may be complicated by the simultaneous formation of, and identification of isomeric 1,2-O-(cyanoalkylidene) derivatives. Hexopyranosyl, pentopyranosyl, and pentofuranosyl cyanides in the D-glucose, D-galactose, D-ribose, and D-xylose series and some isomeric cyanoalkylidene structures have been identified and distinguished by the characteristic chemical shifts of the CN, C-1, and alkylidene <sup>13</sup>C nuclei determined by pulse-Fourier methods at 22.6 MHz. The <sup>13</sup>C-H coupling constants of the cyanoalkylidene derivatives are approximately proportional to the respective <sup>13</sup>C shifts from tetramethylsilane as measured by computer. The acetyl methyl <sup>13</sup>C signals of carbohydrate acetates are often coincident and afford little stereochemical information. For structural analysis, these resonances may be resolved by use of the Eu(fod)<sub>3</sub> or Pr(fod)<sub>3</sub> shift reagents.

**14148.** Daywitt, W. C., **A reference noise standard for millimeter waves**, *IEEE Trans. Microwave Theory Tech.* **MTT-21**, No. 12, 845-847 (Dec. 1973).

Key words: millimeter waves; noise calibration; standard; thermal noise.

The WR15 thermal noise standard that is used as the national reference standard of noise power in the frequency range from 56 to 64 GHz is described in this short paper. The source forms a basis for both the noise-power comparison service and noise-figure service offered by the National Bureau of Standards in this frequency range.

**14149.** Pyke, T. N., Jr., **Some technical considerations for improved service to computer network users**, (Proc. 7th Annual IEEE Computer Conference, San Francisco, Calif., Feb. 27-Mar. 1, 1973), Paper in *Computing Networks from Minis through Maxis—Are they Real?*, *Digest of Papers*, pp. 53-55 (1973).

Key words: computer network; computer service; man-computer interface.

A variety of required and desired communications support services to users of computer networks are described. The general framework for these services is a large resource sharing network in which a number of host computer systems provide service to users through suitable communication facilities. Both interactive and noninteractive users are considered, and some alternatives are outlined for implementation necessary to provide these user services.

**14150.** Unassigned.

**14151.** DiChio, D., Natali, S. V., Kuyatt, C. E., Galejs, A., **Use of matrices to represent electron lenses. Matrices for the two-tube electrostatic lens**, *Rev. Sci. Instrum.* **45**, No. 4, 566-569 (Apr. 1974).

Key words: focal properties; matrix elements; paraxial; strong lenses; two-tube electrostatic lens; weak lenses.

The use of matrices to represent electron lenses is discussed. It is shown that it is more convenient and natural to represent a lens by a matrix and that the matrix elements show a more regular behavior than do the focal properties. Thus matrices are more convenient to use in computer programs. Matrix elements for the two-tube electrostatic lens are presented and their properties discussed. A simple analytical form for the matrix elements of lenses with near-unity voltage ratios is given.

**14152.** Penn, D. R., Plummer, E. W., **Field emission as a probe of the surface density of states**, *Phys. Rev. B* **9**, No. 4, 1216-1222 (Feb. 15, 1974).

Key words: field emission; metal surface; photoemission; surface density of states; total energy distribution.

Field-emission measurements of the total-energy distribution from a clean metal surface are shown to provide information about the density of states near the surface. Specifically, we find the field-emitted current per unit energy at energy  $\omega$  to be given approximately by  $j(\omega) \approx (2\hbar/m)S\lambda^{-2}(\omega)\Sigma_m D_0^2(E_{\perp}^m) \times |\psi_m(\chi_m)|^2 \delta(\omega - \epsilon_m)$ , where  $D_0^2$  is the usual barrier-penetration probability with image potential corrections,  $E_{\perp}^m = \omega - \hbar^2 k_{\parallel}^2/2m$ , where  $k_{\parallel}$  is the electron momentum parallel to the surface,  $|\psi_m(\chi_m)|$  is the amplitude of the metal electron at the classical turning point ( $\chi_m \sim 1-2 \text{ \AA}$ ),  $\lambda(\omega)$  is a slowly varying function of  $\omega$ , and  $S$  is the metal surface area. The  $D_0^2$  factor in  $j(\omega)$  strongly weights electron states with small  $k_{\parallel}$  and consequently  $j(\omega)$  measures the density of states at  $\chi_m$  arising from the component of the bulk band structure normal to the surface. Measurements of  $j(\omega)$  for several single-crystal planes of tungsten will be presented and compared to the relevant photoemission data.

**14153.** Fowlkes, C. W., **Fracture toughness tests of a rigid polyurethane foam**, *Int. J. Fract.* **10**, No. 1, 99-108 (Mar. 1974).

Key words: fracture; fracture toughness; polyurethane foam.



The results of some exploratory tests for determining the fracture toughness of a rigid polyurethane foam are presented. The specimen geometries used included center- and double-edge-cracked plates, the single-edge-cracked tensile specimen and the double cantilever beam specimen. The validity of applying the concepts of linear elastic fracture mechanics to the fracture of this foam is discussed. Some unique features of the fracture of foam are discussed.

- 14154.** Fatiadi, A. J., **New applications of periodic acid and periodates in organic and bio-organic chemistry**, *Synthesis Reviews*, No. 4, 229-272 (Apr. 1974).

Key words: application; bio-organic; methods; organic; oxidation; periodates; review.

Recent applications of periodic acid and periodates to organic and bio-organic chemistry are reviewed. Unique periodate oxidations and synthetic methods employing periodates are discussed.

- 14155.** Bagchi, A., Gomer, R., Penn, D. R., **The field emission total energy distribution in the presence of adsorbates**, *Surface Sci.* **41**, 555-558 (1974).

Key words: adsorbed molecules on metal surfaces; Anderson Model; energy distribution of field emitted electrons; field emission theory; metal surface; overcomplete states.

The total energy distribution (TED) of field-emitted electrons from an adsorbate-covered metal surface is studied within the framework of the Anderson Hamiltonian, but taking over-completeness of states into account. The correct asymptotic behavior of the adsorbate wavefunction, postulated in the previous work, is now established, and a numerical correction factor ( $\sim 15$ ) to the adsorbate induced current density is obtained.

- 14156.** Farabaugh, E. N., **X-ray microscopy of single-crystal potassium dideuterium phosphate**, *J. Appl. Phys. Commun.* **45**, No. 4, 1905-1907 (Apr. 1974).

Key words: dislocations; KD\*P; Lang technique; solution grown; x-ray diffraction microscopy.

Examination of solution-grown KD\*P single crystals by the Lang technique has shown that the crystals are free from growth veils, impurity segregation, and subgrain boundaries. The density of dislocations varies throughout the volume of the crystals, some areas being nearly dislocation free. One Burgers vector identified as being parallel to  $\langle 100 \rangle$  is common to the similar KDP and ADP single crystals.

- 14157.** Bonnelle, C., Karnatak, R. C., Sugar, J., **Photoabsorption in the vicinity of 3d absorption edges of La, La<sub>2</sub>O<sub>3</sub>, Ce, and CeO<sub>2</sub>**, *Phys. Rev. A* **9**, No. 5, 1920-1923 (May 1974).

Key words: absorption; Ce; La; x rays.

Observations of photoabsorption in La, La<sub>2</sub>O<sub>3</sub>, Ce, and CeO<sub>2</sub>, in the vicinity of the 3d edges are given. Calculations of relative absorption intensities for Ce are shown to correspond well with the experimental data.

- 14158.** Negas, T., Roth, R. S., Parker, H. S., Minor, D., **Subsolidus phase relations in the BaTiO<sub>3</sub>-TiO<sub>2</sub> system**, *J. Solid State Chem.* **9**, 297-307 (1974).

Key words: barium-titanium oxides; BaTiO<sub>3</sub>-TiO<sub>2</sub> system; crystal structure; phase equilibria.

Ba<sub>6</sub>Ti<sub>17</sub>O<sub>40</sub>, Ba<sub>4</sub>Ti<sub>13</sub>O<sub>30</sub>, BaTi<sub>4</sub>O<sub>9</sub>, and Ba<sub>2</sub>Ti<sub>9</sub>O<sub>20</sub> are the only compounds which were found to have a stability range in the subsolidus of the BaTiO<sub>3</sub>-TiO<sub>2</sub> system. BaTi<sub>2</sub>O<sub>5</sub> and BaTi<sub>5</sub>O<sub>11</sub>, reported in other studies, apparently are not stable. The compound reported as Ba<sub>2</sub>Ti<sub>5</sub>O<sub>12</sub> appears to have been mistaken for Ba<sub>6</sub>Ti<sub>17</sub>O<sub>40</sub>. X-ray diffraction powder data are given for this

phase which is monoclinic with  $a=9.890$ ,  $b=17.117$ ,  $c=18.933$  Å and  $\beta=98^\circ 42.6'$ . The phase formulated previously as BaTi<sub>3</sub>O<sub>7</sub> is shown to be Ba<sub>4</sub>Ti<sub>13</sub>O<sub>30</sub> based on structural and density considerations, phase equilibria, and single crystal and powder x-ray diffraction data. This compound is orthorhombic with  $a=17.072$ ,  $b=9.862$ , and  $c=14.059$  Å, probable space group, *Cmca*. An idealized structure for this phase is proposed. Ba<sub>2</sub>Ti<sub>9</sub>O<sub>20</sub> decomposes above 1300 °C in the solid state to BaTi<sub>4</sub>O<sub>9</sub> plus rutile. Single crystals were grown using BaF<sub>2</sub> as a mineralizer.

- 14159.** Jones, M. C., Giarratano, P. J., McConnell, P. M., Arp, V., **Refrigeration with forced flow of helium**, *Proc. Cryogenic Cooler Conf., USAF Academy, Colorado Springs, Colo., Oct. 16-17, 1973*, pp. 441-462 (Air Force Flight Dynamics Laboratory (FEC), Wright-Patterson Air Force Base, Ohio, Dec. 1973).

Key words: forced flow; heat transfer; helium; pump; refrigeration.

The operation of practical superconducting components usually generates some heat because of nonideality of the superconductors, particularly in a.c. applications. In many cases, e.g., pulsed magnets, system design and performance is strongly constrained by the available heat transfer between the superconductor and the surrounding helium. We have been studying the general problems of maintaining the required refrigeration by forced flow of helium.

The desired helium flow can be obtained either directly from the refrigerator system (i.e., room temperature compressors) or from auxiliary pumps which offer additional system flexibility at the cost of probable additional thermal load on the refrigerator. We have evaluated centrifugal pump performance in superfluid, normally boiling, and supercritical helium, with results in approximate accord with scaling laws and pump performance measurements in other fluids. Cavitation limits and other performance considerations in helium will be presented.

- 14160.** Rook, H. L., LaFleur, P. D., Sudduth, J. E., **Trace element determination using a high yield electromagnetic isotope separator and neutron activation—the determination of cadmium**, *Nucl. Instrum. Methods* **116**, 579-586 (1974).

Key words: cadmium; high yield mass separator; neutron activation.

The use of isotope separators capable of producing high beam currents as applied to neutron activation analysis is discussed. The specificity of mass separation in this application allows beta or gross gamma counting to be used thereby providing increased sensitivity. The definition of instrument operational parameters and capabilities are discussed. Such parameters as yield, memory, resolution, overlap, and sputtering are considered. The optimized use of the mass separator as applied to the determination of cadmium in submicrogram quantities is presented.

- 14161.** McCulloh, K. E., Walker, J. A., **Photodissociative formation of ion pairs from molecular hydrogen and the electron affinity of the hydrogen atom**, *Chem. Phys. Lett.* **25**, No. 3, 439-442 (Apr. 1, 1974).

Key words: deuterium; electron affinity; hydrogen atom; ion-pair formation; para-hydrogen; photodissociation.

Photodissociative production of ion pairs from H<sub>2</sub> has been observed in the wavelength range 706-718 Å at spectral resolutions of 0.4 and 0.22 Å. From measured thresholds for production of H<sup>-</sup> from H<sub>2</sub> molecules in each of the three lowest rotational states, the lower bound  $EA(H) \geq 0.754 \pm 0.002$  eV is obtained, in excellent agreement with the theoretical electron affinity of 0.75421 eV. For formation of D<sup>-</sup> from D<sub>2</sub>, a threshold assigned to molecules in the rotational state  $J=2$  has been mea-



sured, from which the bound  $EA(D) \geq 0.757 \pm 0.005$  eV is obtained. Negative ion yield curves are presented for hydrogen.

- 14162.** Yates, J. T., Jr., Madey, T. E., Erickson, N. E., **ESCA study of carbon monoxide and oxygen adsorption on tungsten**, *Surface Sci.* **43**, 257-274 (1974).

Key words: carbon monoxide; chemical shift; chemisorption; ESCA; oxygen; tungsten.

The chemisorption of both CO and O<sub>2</sub> on a clean tungsten ribbon has been studied using an ultrahigh vacuum x-ray photoelectron spectrometer. For CO, the energy and intensity of photoemission from O(1s) and C(1s) core levels have been studied for various adsorption temperatures.

At adsorption temperatures of  $\sim 100$  K, the "virgin"-CO state was the dominant adsorbed species. Conversion of this state to more strongly-bound  $\beta$ -CO is observed upon heating the adsorbed layer to  $\sim 320$  K. Thermal desorption of CO at  $300 \leq T \leq 640$  K causes sequential loss of  $\alpha_1$ -CO and  $\alpha_2$ -CO as judged by the disappearance of O(1s) and C(1s) photoelectron peaks characteristic of these states.

Oxygen adsorption at 300 K gives a single main O(1s) peak at all coverages, although at high oxygen coverages there exist small auxiliary peaks at  $\sim 2$  eV lower kinetic energy. The photoelectron C(1s) and O(1s) binding energies observed for these adsorbed species are all lower than for gaseous molecules containing C and O atoms. For CO adsorption states there is a systematic decrease in photoelectron binding energy as the strength of adsorption increases. These observations are in general accord with expectations based on electronic relaxation effects in condensed materials.

- 14163.** Van Brunt, R. J., Kieffer, L. J., **Electron energy dependence of the energy and angular distributions of O<sup>-</sup> from dissociative ion pair formation in O<sub>2</sub>**, *J. Chem. Phys.* **60**, No. 8, 3057-3063 (Apr. 15, 1974).

Key words: dissociation; electron; ionization; molecular oxygen.

The energy and angular distributions of O<sup>-</sup> produced from O<sub>2</sub> by dissociative ion pair formation have been measured at selected incident electron energies from threshold to 100 eV. The kinetic energy distributions show well-defined maxima near 2.0 and 3.3 eV with appearance potentials, respectively, at 20.0 and 23.0 eV. The angular distributions are peaked in the forward and backward directions relative to electron beam and exhibit nondipolar structure. The shape of the distributions depends on electron energy, becoming more isotropic with increasing energy. An attempt has been made to explain the behavior of the angular distributions in terms of a superposition of final states using a multipole expansion of the differential cross section which includes the effects of higher-order partial waves.

- 14164.** Diller, D. E., **The Clausius-Mossotti functions (molar polarizabilities) of pure compressed gaseous and liquid methane, ethane, propane, butanes, and nitrogen**, *Cryogenics* **14**, No. 4, 215-216 (Apr. 1974).

Key words: butanes; Clausius-Mossotti function; density; dielectric constant; ethane; interpolation function; LNG components; methane; mixtures; nitrogen; propane.

This report gives accurate interpolation functions for the Clausius-Mossotti functions (molar polarizabilities) of pure compressed gaseous and liquid methane, ethane, propane, butanes and nitrogen; and suggests a method for calculating the dielectric constants or the densities of their mixtures. The accuracy of calculated Clausius-Mossotti functions for mixtures containing a high concentration of methane is expected to be better than 1 percent using only data for the pure components. Additional data for the dependence of the excess Clausius-Mossotti function on

composition could reduce the uncertainty in Clausius-Mossotti functions for multicomponent mixtures to less than 0.2 percent.

- 14165.** Gadzuk, J. W., **Surface molecules and chemisorption. I. Adatom density of states**, *Surface Sci.* **43**, 44-60 (1974).

Key words: chemisorption; molecules; surfaces.

A useful picture of chemisorption on metal surfaces is one in which a localized molecule is formed between the adatom and its nearest neighbor substrate atoms. The interaction responsible for the molecule formation is treated as the coupling between the adsorbate state and a group orbital formed from a linear combination of atomic orbitals on the substrate atoms. Within the surface molecule picture, level width and level shift functions, given by Newns modification of the Anderson theory, have been calculated and the resulting adatom density of states function has been obtained. This has been done for model systems in which the substrate is either a free electron metal or a tightbinding p-band metal and the adsorbate is s or p like. The results show how it is possible to simultaneously have narrow virtual levels due to chemisorption ( $\sim 1$  eV) which previously implied weak interactions and also high binding energies ( $> 3$  eV) as are observed experimentally.

- 14166.** Gilman, F. J., Kugler, M., Meshkov, S., **Transformation between current and constituent quarks and transitions between hadrons**, *Phys. Rev. D* **9**, No. 3, 715-735 (Feb. 1, 1974).

Key words: cross sections; reactions; regge pole; SU(3); symmetry breaking; trajectory.

The transformation from current- to constituent-quark basis states is discussed. Certain algebraic properties of the transformed vector and axial-vector currents are abstracted from the free-quark model and assumed to hold in nature. Supplemented by the partially conserved axial-vector current hypothesis and assumptions about the identification of the observed hadrons with simple constituent-quark states, the algebraic properties of the transformed currents are used to compute the pion and photon transitions between any two hadron states. General selection rules are stated. Many specific matrix elements for both meson and baryon decays are tabulated, and both their magnitudes and signs are compared with experiment.

- 14167.** McDonald, D. G., Peterson, F. R., Cupp, J. D., Davidson, B. L., Johnson, E. G., **Josephson junctions at 45 times the energy-gap frequency**, *Appl. Phys. Lett.* **24**, No. 7, 335-337 (Apr. 1, 1974).

Key words: cryogenics; infrared; Josephson junctions; lasers; superconductivity.

Superconductive Nb-Nb point contacts have been studied with 9.5- $\mu$ m radiation from CO<sub>2</sub> lasers. Two models are considered to explain the experiments: one is Werthamer's Josephson junction model and the other is a thermally modulated Josephson junction. The evidence favors Werthamer's model but is not conclusive.

- 14168.** Haque, S. S., Lees, R. M., Saint Clair, J. M., Beers, Y., Johnson, D. R., **Microwave spectrum of <sup>13</sup>C methanol**, *Astrophys. J.* **187**, L-15 - L-17 (Jan. 1, 1974).

Key words: carbon-13; methanol.

Laboratory measurements of the frequencies of some astronomically interesting transitions of the <sup>13</sup>C isotopic species of methanol are reported. Most lines of the  $J = 2 \leftarrow 1$ ,  $3 \leftarrow 2$ ,  $4 \leftarrow 3$   $\mu_a$ -type  $\Delta k = 0$  transitions in the 94-, 142-, and 189-GHz regions have been measured, as well as a number of  $\mu_b$ -type transitions in the 14-50 GHz region. The standard deviation of fit with the constants given is 0.098 MHz. The remaining unmeasured lines in these R-branch patterns have been predicted with an uncertainty of 0.3 MHz.



14169. Unassigned.

14170. DiChio, D., Natali, S. V., Kuyatt, C. E., **Focal properties of the two-tube electrostatic lens for large and near-unity voltage ratios**, *Rev. Sci. Instrum.* **45**, No. 4, 559-565 (Apr. 1974).

Key words: focal properties; near-unity voltage ratios; object-image curves; paraxial; two-tube electrostatic lens; weak lenses.

Accurate calculations of focal properties of the two-tube electrostatic lens are extended to cover a range of voltage ratios from 1.1 to 10000. The accuracy of the calculations is discussed in detail. For voltage ratios near 6400 the lens is found to be telescopic. Results are given in tabular form and as  $P$ - $Q$  (object-image) curves. A simple analytical form for the focal properties of lenses with near-unity voltage ratios is given.

14171. Roder, H. M., **ASRDI oxygen technology survey. Volume V: Density and liquid level measurement instrumentation for the cryogenic fluids oxygen, hydrogen, and nitrogen**, *NASA Spec. Publ.* **3083**, 67 pages (National Aeronautics and Space Administration, Washington, D.C., 1974).

Key words: density; instrumentation; liquid level; phase detection; quantity gaging.

This volume of the survey presents information on instrumentation for density measurement, liquid level measurement, quantity gaging, and phase measurement. Information directly concerned with oxygen was given primary emphasis, work not specifically designated for oxygen, but considered of potential value in oxygen service was included. The information available on each instrument is presented under the headings: reference(s), instrumentation type, physical principle, phase of operation, a description of the instrument, materials of construction significant to oxygen compatibility, calibration method, performance characteristics, oxygen service, and limitations. The report also presents a discussion of problem areas in density and liquid level measurement, and recommends areas for further research and development.

14172. Naimon, E. R., Weston, W. F., Ledbetter, H. M., **Elastic properties of two titanium alloys at low temperatures**, *Cryogenics* **14**, No. 5, 246-249 (May 1974).

Key words: bulk modulus; compressibility; Debye temperature; elastic constant; Poisson's ratio; shear modulus; sound velocity; titanium alloys; Young's modulus.

Sound velocities and elastic constants were determined semi-continuously for two annealed polycrystalline titanium alloys between 4 and 300 K. Results are given for: longitudinal sound velocity, transverse sound velocity, Young's modulus, shear modulus, bulk modulus, Poisson's ratio, and elastic Debye temperature. A pulse-superposition technique was used.

14173. McCarty, R. D., **A modified Benedict-Webb-Rubin equation of state for methane using recent experimental data**, *Cryogenics* **14**, No. 5, 276-280 (May 1974).

Key words: equation of state; methane.

A 33 term modified Benedict-Webb-Rubin equation of state is presented for methane. The adjustable parameters in the equation of state have been estimated using recent experimental data and least squares techniques which include the thermodynamic equilibrium conditions for the co-existing liquid and vapour phases. Comparisons of the new equation of state and an older modified Benedict-Webb-Rubin equation of state to experimental data are given.

14174. Broadhurst, M. G., Malmberg, C. G., Mopsik, F. I., Harris, W. P., **Piezo- and pyroelectricity in polymer electrets**, (Proc. Conf. on Electrets, Charge Storage and Transport in Dielectrics, Miami Beach, Fla., Oct. 8-13, 1972), Chapter in

*Electrets, Charge Storage and Transport in Dielectrics*, M. M. Perlman, Ed., pp. 492-504 (Electrochemical Society, New York, N.Y., 1973).

Key words: dipoles; electret; glass transition; polymer; pyroelectric.

A model for a polymer electret, based on an elastically isotropic solid with orientationally frozen molecular dipoles, was developed and tested experimentally. This electret is shown to be both piezoelectric and pyroelectric. The polarization is shown to change with mechanically and thermally induced strains in the polarization direction. The currents generated by the electret will be proportional to the strain rate and, for thin contact electrodes and uniform strains, unaffected by the presence of real charges. Poly (vinyl chloride) films were poled at 80 °C, just above their glass transition temperature. The pressure- and temperature-induced short-circuit currents in the polarization direction equalled 0.15(pA/cm<sup>2</sup>)/(bar/min) and 2.2 (pA/cm<sup>2</sup>)/(K/min) respectively for a specimen poled at 320 kV/cm. These currents were 1) reversible and proportional to the rate of temperature or pressure change, 2) proportional to poling voltage up to 320 kV/cm, 3) in the direction corresponding to increasing polarization with increasing pressure and decreasing temperature, 4) stable with time without special storage conditions, 5) about 1.6 times as great for temperature induced strains as for equivalent pressure induced strains and 6) about 2-4 times as great in magnitude as expected from dielectric constant measurements. The apparent polarization from temperature measurements for the 320 kV/cm specimen was about 1.7  $\mu$ C/cm<sup>2</sup>, or about 1/3 the value expected for maximum alignment of dipoles. In the same specimen the pyroelectric coefficient was found to be  $p_3 = -0.39$  nC/cm<sup>2</sup> K and, assuming elastic isotropy, the piezoelectric strain coefficients were found to be  $d_{31} = d_{32} = d_{33} = -0.89$  pC/N.

14175. Powell, R. L., Fickett, F. R., Birmingham, B. W., **Programs on large scale applications of superconductivity in the United States**, (Proc. NATO Advanced Study Institute, Superconducting Machines and Devices-Large Systems Applications, Entreves, Italy, Sept. 5-14, 1973), Chapter 17 in *Superconducting Machines and Devices-Large Systems Applications*, S. Foner and B. B. Schwartz, Eds., pp. 651-675 (Plenum Publishing Corp., New York, N.Y., 1974).

Key words: electrical machinery; land transportation; power transmission; propulsion systems; superconducting devices; superconducting magnets; superconductivity.

A brief overview is given of U.S. programs on large-scale applications of superconductivity. Tables are presented listing for each project: the organization; the manager; a description of the device; a comment on the type of program; the source and amount of funding; the current status and the projected plans. The seven major project categories are: (1) Generators for electric power systems; (2) Power transmission; (3) Machinery for propulsion systems; (4) Magnets for energy storage, MHD and CTR systems; (5) Magnets and cavities for high energy physics experiments; (6) Magnets for industrial and medical applications; (7) Land transportation systems.

14176. Brennan, J. A., **LNG measurement projects at NBS**, *Proc. 49th Int. School of Hydrocarbon Measurement, Norman, Okla., Apr. 16-18, 1974*, pp. 464-465 (1974).

Key words: description; LNG; projects.

This paper presents, in summary form, the projects at the Cryogenics Division of NBS involved with LNG or LNG related measurements. A brief description of each project is given along with identification of the sponsoring agency.

14177. Krauss, M., Neumann, D., **Multi-configuration self-consistent-field calculation of the dissociation energy and electronic structure of hydrogen fluoride**, *Mol. Phys.* **27**, No. 4, 917-921 (1974).



**Key words:** configuration interaction; dipole moment; dissociation energy; electronic structure; HF; quadrupole moment.

The optimized valence configuration method of Wahl and Das is applied to a study of the electronic structure of FH at the equilibrium internuclear separation. A compact eight configuration wave function is found to yield an accurate dissociation energy and dipole moment.

- 14178.** Soulen, R. J., Jr., **Calibration of paramagnetic thermometers using superconductive fixed points**, *Cryogenics* **14**, No. 5, 250-252 (May 1974).

**Key words:** fixed points; paramagnetism; superconductivity; temperature.

A new method for calibration of paramagnetic materials is described. The technique consists of fitting the temperature-dependent mutual inductance of a coil set surrounding a paramagnetic material to a Curie Law using the superconductive transitions of several elements as thermometric fixed points. As a particular demonstration of this technique, the paramagnetic salt, cerous magnesium nitrate, was calibrated using the superconductive transitions of aluminium, zinc, and cadmium. The temperature scale obtained in this way was used in a study of the superconductive properties of iridium.

- 14179.** Chang, S. S., Bestul, A. B., **Heat capacities of selenium crystal (trigonal), glass, and liquid from 5 to 360 K**, *J. Chem. Thermodyn.* **6**, 325-344 (1974).

**Key words:** annealed and quenched glasses; calorimetry; glass transformation; heat capacity; selenium; supercooled liquid; thermodynamic properties; trigonal selenium.

Heat capacities of high purity selenium (better than 99.999 moles percent) have been measured for the trigonal crystal from 5 to 360 K, for the quenched and annealed glasses from 5 K to  $T_g$  (around 300 K) and for the supercooled liquid from  $T_g$  to 340 K. The glass transformation temperature  $T_g$ , as determined from plots of  $H$  against  $T$ , is 304 K for the quenched glass and 295 K for the annealed glass.  $C_p$  of the glass is higher than that of the crystal over the entire temperature range of investigation.  $C_p$  { $H(T) - H(c, 0)$ }, and  $S$  for the trigonal form of Se at 298.15 K are 25.05 J K<sup>-1</sup> mol<sup>-1</sup>, 5509 J mol<sup>-1</sup>, and 42.27 J K<sup>-1</sup> mol<sup>-1</sup>, respectively. The corresponding thermodynamic properties of the annealed Se glass at 298.15 K, evaluated by incorporating the present results with recently published high-temperature data, are 26.23 J K<sup>-1</sup> mol<sup>-1</sup>, 9363 J mol<sup>-1</sup>, and 48.60 J K<sup>-1</sup> mol<sup>-1</sup>, respectively. The residual entropy of the annealed Se glass is estimated to be 3.6 J K<sup>-1</sup> mol<sup>-1</sup> at  $T = 0$ .

- 14180.** Walls, F. L., Dunn, G. H., **Measurement of total cross sections for electron recombination with NO<sup>+</sup> and O<sub>2</sub><sup>+</sup> using ion storage techniques**, *J. Geophys. Res.* **79**, No. 13, 1911-1915 (May 1, 1974).

**Key words:** ion storage technique; recombination of NO<sup>+</sup>; recombination of O<sub>2</sub><sup>+</sup>.

The total cross section as a function of electron energy for recombination of electrons with room temperature NO<sup>+</sup> has been measured with a trapped ion technique. Measurements were made in the electron energy range 0.045-4 eV with an energy resolution between 0.045 and 0.120 eV, and the cross sections, which showed some structure, ranged from  $1.25 \times 10^{-14}$  cm<sup>2</sup> at the lowest energy to  $1.7 \times 10^{-16}$  cm<sup>2</sup> at the highest energy. Similar measurements were made on O<sub>2</sub><sup>+</sup>, the species used to calibrate the apparatus geometry. A Maxwellian distribution of electron velocities was used with the measured cross sections to calculate rate constants, giving values extending to electron temperatures as high as 40,000 K. Comparison with previously measured rate coefficients at lower temperatures is quite satisfactory.

- 14181.** Burke, J. M., Ritter, J. J., Lafferty, W. J., **Infrared and Raman spectra of ethynyldifluoroborane (HC<sub>2</sub>BF<sub>2</sub>) and ethynyl-dichloroborane (HC<sub>2</sub>BCl<sub>2</sub>)**, *Spectrochim. Acta* **30A**, 993-999 (1974).

**Key words:** ethyldifluoroborane; ethynyldichloroborane; gas phase; infrared; Raman; spectra.

The vapor phase infrared and Raman spectra of several isotopic species of ethynyldifluoroborane (HC<sub>2</sub>BF<sub>2</sub>) and ethynyldichloroborane (HC<sub>2</sub>BCl<sub>2</sub>) have been obtained. Vapor phase band contours, Raman polarization data, characteristic group frequencies, and isotopic frequency shifts have been used to make the vibrational assignments for these molecules.

- 14182.** Risley, E. W., Jr., **Discontinuity capacitance of a coaxial line terminated in a circular waveguide. II. Lower bound solution**, (Proc. Conf. Precision Electromagnetic Measurement, Boulder, Colo., June 26-29, 1972), *CPEM Digest*, p. 111 (1972).

**Key words:** coaxial line reactance termination; discontinuity capacitance; lower bound.

The standard of reflection for coaxial line is the quarter wave short circuit termination. There are shortcomings to this standard; the fabrication cost is high and each termination is usable at only one frequency. However, an open-circuited coaxial line with extended outer conductor and solid inner conductor could be used advantageously as a standard termination because fabrication can be made using commercially available components, the device is broad-banded and losses are minimal. In addition to the high-frequency application, the termination can also be used at low frequencies as a standard of capacitance.

In an earlier paper (Discontinuity Capacitance of a Coaxial Line Terminated in a Circular Waveguide, Vol. MTT-17, No. 2, Feb. 1969), the input admittance  $y_{in}$  of this termination was calculated, assuming perfect conductivity, using a variational technique. A stationary form was derived for  $y_{in}$  which determined an *upper bound* to the discontinuity capacitance of the termination.

- 14183.** Drummond, D. L., Gallagher, A., **Potentials and continuum spectra of Rb-noble gas molecules**, *J. Chem. Phys.* **60**, No. 9, 3426-3435 (May 1, 1974).

**Key words:** molecules; rubidium.

Rubidium vapor is optically excited by either of the atomic resonance lines in the presence of typically 400 torr of He, Ne, Ar, Kr, or Xe. Normalized emission spectra of the far wings of these resonance lines are then measured as a function of temperature. These far wings, extending as much as 1000 Å from the resonance lines, are interpreted as molecular continuum radiation of Rb-noble gas molecules. Using the quasistatic theory of line broadening, or the classical Franck-Condon principle, these spectra are analyzed to yield the ground and excited state molecular potentials.

- 14184.** Carrington, C. G., Gallagher, A., **Teratomic recombination of excited RbXe**, *J. Chem. Phys.* **60**, No. 9, 3436-3444 (May 1, 1974).

**Key words:** molecules; recombination.

Free Rb(5 <sup>2</sup>S) is optically excited to Rb\*(5 <sup>2</sup>P<sub>1/2</sub>) in the presence of Xe gas, and the RbXe\*(A <sup>2</sup>Π<sub>1/2</sub>) → RbXe(X <sup>2</sup>Σ<sub>1/2</sub>) fluorescence is measured as a function of xenon pressure. The teratomic recombination process, Rb\* + 2Xe → RbXe\* + Xe, and other collision processes compete with radiative decay. The radiative rate is known, so collisional rates can be inferred from the data. The molecular spectrum is observed as a continuum, whose intensity profile yields the bound-state vibrational distribution at each xenon pressure. The low-pressure limit of this



distribution yields the teratomic recombination rate as a function of vibrational state, and the total recombination rate constant  $k_f$ . The recombination rate into a bound state increases with increasing binding energy, but less rapidly than the increase in equilibrium population. The transition from this initially formed distribution to the high-pressure equilibrium distribution is reported. The ratio  $k_f/K_{eq} = 2.4 \times 10^{-11}$  cm<sup>3</sup>/sec and the equilibrium constant  $K_{eq} \approx 3.4 \times 10^{-21}$  cm<sup>3</sup>, corresponding to the experimental temperature of 300 K, are deduced from the data. The  $A^2\Pi_{1/2}$  and  $X^2\Sigma_{1/2}$  potentials are also obtained from analysis of the spectrum in the low-pressure and high-pressure limits.

**14185.** Roth, R. S., Parker, H. S., Brower, W. S., Minor, D., **Alkali oxide-tantalum oxide and alkali oxide-niobium oxide ionic conductors**, *NASA CR-134599*, 60 pages (National Aeronautics and Space Administration, Washington, D.C., Apr. 1974).

Key words: alkali ions; ionic conductors; niobates; tantalates.

A search was made for new cationic conducting phases in alkali-tantalate and niobate systems. The phase equilibrium diagrams were constructed for the six binary systems Nb<sub>2</sub>O<sub>5</sub>-LiNbO<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>-NaNbO<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>-KNbO<sub>3</sub>, Ta<sub>2</sub>O<sub>5</sub>-LiTaO<sub>3</sub>, Ta<sub>2</sub>O<sub>5</sub>-NaTaO<sub>3</sub> and Ta<sub>2</sub>O<sub>5</sub>-KTaO<sub>3</sub>. Various other binary and ternary systems were also examined. Pellets of nineteen phases were evaluated (by the sponsoring agency) by dielectric loss measurements. Attempts were made to grow large crystals of eight different phases. The system Ta<sub>2</sub>O<sub>5</sub>-KTaO<sub>3</sub> contains at least three phases which showed peaks in dielectric loss vs. temperature. All three contain structures related to the tungsten bronzes with alkali ions in nonstoichiometric crystallographic positions.

**14186.** Fickett, F. R., **Oxygen annealing of copper: A review**, *Mater. Sci. Eng.* **14**, No. 3, 199-210 (June 1974).

Key words: annealing; copper; oxidation; purification.

A useful technique for significantly increasing the low temperature electrical conductivity of copper is heating in the presence of a reduced pressure of oxygen. The same technique is sometimes used on dilute alloys to produce dispersion hardening by oxide particles. This paper reviews the literature on the oxidation process in copper. Particular emphasis is on oxidation to increase conductivity. A set of conditions for a purifying anneal are presented. A brief discussion of dispersion hardening by oxidation and of several chemisorption experiments is included.

**14187.** Radford, H. E., Evenson, K. M., Howard, C. J., **HO<sub>2</sub> detected by laser magnetic resonance**, *J. Chem. Phys.* **60**, No. 8, 3178-3183 (Apr. 15, 1974).

Key words: free radical; HO<sub>2</sub>; laser magnetic resonance.

Far-infrared absorption spectra of HO<sub>2</sub> in the gas phase have been detected at six wavelengths of a water vapor laser magnetic resonance spectrometer. The identification of HO<sub>2</sub> as the absorbing molecule is based on a partial analysis of the spectra and on a variety of different chemical methods used to produce the radical. Approximate values of rotational constants and spin doublet separations are derived from the spectra.

**14188.** Stephenson, J. C., Mosburg, E. R., Jr., **Vibrational energy transfer in CO from 100 to 300 K**, *J. Chem. Phys.* **60**, No. 9, 3562-3566 (May 1, 1974).

Key words: carbon monoxide; CO<sub>2</sub> lasers; combustion; optical pumping of molecules; vibrational relaxation.

The laser fluorescence method, whereby CO molecules are optically pumped from the vibrational level  $v=0$  to the  $v=1$  state by frequency-doubled pulses from a CO<sub>2</sub> laser, has been used to determine vibrational energy transfer rate coefficients for CO. Rates for the  $V-V$  exchange processes  $\text{CO}(0) + \text{N}_2(1) \rightarrow$

$\text{CO}(1) + \text{N}_2(0)$  and  $\text{CO}(1) + \text{CO}(1) \rightarrow \text{CO}(0) + \text{CO}(2)$ , and for the deactivation of CO(1) by H<sub>2</sub> have been measured in the range  $100 \text{ K} \leq T \leq 300 \text{ K}$ . The probability of energy transfer from N<sub>2</sub> to CO decreases slightly as  $T$  decreases in this range, while the probability of the CO-CO  $V-V$  process is approximately proportional to  $T^{-1}$ . Rate coefficients were also measured at  $T=297 \text{ K}$  for the deactivation of CO(1) by the polyatomic molecules CH<sub>4</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, HCOOH, CH<sub>3</sub>COOH, CH<sub>3</sub>CHO, CH<sub>3</sub>OH, C<sub>2</sub>H<sub>5</sub>OH, H<sub>2</sub>O, D<sub>2</sub>O, H<sub>2</sub>S, and C<sub>4</sub>H<sub>10</sub>.

**14189.** Ambrose, J. R., Kruger, J., **Tribo-ellipsometric study of the repassivation kinetics of a Ti 8Al-1Mo-1V alloy**, *J. Electrochem. Soc.* **121**, No. 5, 599-604 (May 1974).

Key words: repassivation kinetics; stress corrosion cracking; titanium alloy; tribo-ellipsometry.

The tribo-ellipsometric technique allows one to distinguish between film growth and other reactions that occur after removal of a film from a metal surface in a given environment. This technique was used to study the relationship between repassivation kinetics and stress corrosion cracking (SCC) susceptibility for Ti 8Al-1Mo-1V alloy. In these studies the effect of the rate of film growth on the amount of metal dissolution which occurs during the repassivation process was investigated by comparing the repassivation transient behavior in a 1.0N NaCl solution, where cracks have been found to propagate, to that in a 1.0N NaNO<sub>3</sub> solution where SCC susceptibility has never been detected. Film growth kinetics in both solutions were consistent with a Fleischmann-Thirsk mechanism of oxide patch nucleation and two-dimensional growth, although the film growth rate was significantly slower in the 1.0N NaCl solution. Low film growth rate led to an increase in metal dissolution in a solution where crack propagation velocities have been measured, but at an apparent rate slower than necessary to propagate such cracks by metal dissolution alone.

**14190.** Page, C. H., **Tetrahedral junction error contribution to a series-parallel four-terminal resistor**, *IEEE Trans. Instrum. Meas.* **IM-23**, No. 1, 5-8 (Mar. 1974).

Key words: four-terminal; Hamon divider; resistance network; series-parallel; tetrahedral junction.

The errors of a series-parallel four-terminal resistor build-up box due to imperfections in the tetrahedral junctions are analyzed. It is shown how these errors can be made negligible by choosing orientations of the junctions.

**14191.** Allpress, J. G., Iijima, S., Roth, R. S., Stephenson, N. C., **Structural studies by electron microscopy: High-resolution observations on  $\beta\text{-ZrO}_2 \cdot 12\text{Nb}_2\text{O}_5$** , *J. Solid State Chem.* **7**, 89-93 (1973).

Key words:  $\beta\text{-ZrO}_2 \cdot 12\text{Nb}_2\text{O}_5$ ; electron microscopy; high resolution; structural studies.

Reliable idealized structures for the  $\beta$  and  $\gamma$  forms of  $\text{ZrO}_2 \cdot 12\text{Nb}_2\text{O}_5$  have been deduced following the observation of lattice images, recorded at a resolution of about 0.3 nm, from crystals oriented with their short  $b$  axes parallel to the incident electron beam. The structure of the  $\beta$  form is confirmed by preliminary results from single crystal x-ray studies. The present observations are compared with previous work on these phases.

**14192.** Swartzendruber, L. J., Bennett, L. H., Schoefer, E. A., DeLong, W. T., Campbell, H. C., **Mössbauer-effect examination of ferrite in stainless steel welds and castings**, *Weld. J.* **39**, No. 1, 1-S-12-S (Jan. 1974).

Key words: backscattering; casting; ferrite; Mössbauer; stainless steel; welding.

The differences between wholly austenitic, single phase stainless steels and those with two phase, partially ferritic structures



have assumed commercial importance in recent years, but full utilization of the benefits to be derived from such two phase materials has been hampered by difficulties in establishing their exact ferrite contents.

The Mössbauer-effect scattering method measures the relative amounts of the austenite and ferrite phases on the basis of their magnetic properties in a way which is relatively independent of the shape, size and orientation of the ferrite particles.

**14193.** Robertson, A. F., **Effluent fire product—A crude approach to fire gas hazard assessment**, *Fire Technol.*, pp. 115-128 (May 1974).

Key words: effluent fire product; fire gas; fire hazard; gas hazard; hazard analysis; insulation; loss on ignition; potential heat.

A method is proposed for classifying the various factors influencing the life safety hazard posed during fires. Five fire hazard components are identified; these include oxygen deficiency, toxic combustion products, smoke particulates, hot gases and flame exposure. It is shown that the relative importance of these can be influenced by a number of hazard modifiers. These have been subdivided into three classes, those related to the material or product under consideration, those influenced by the fire location or degree of confinement and those associated with the people exposed.

It seems premature to try to evaluate in a quantitative way the influence of these many modifiers on the overall life hazard. However, it may serve a useful purpose in ranking materials or products with regard to the fire gas hazard to assume this is a function of the loss on ignition or the effluent fire product (EFP). An example of the usefulness of this concept is presented by a method for use of EFP in ranking insulation materials in such a manner that proper recognition is taken of their thermal properties.

A procedure making use of the potential heat test is proposed to permit avoidance of erroneously high value of EFP as a result of weight loss resulting from combined water and other inert components.

**14194.** Newman, M., **Modular quotient groups**, *Ill. J. Math.* **18**, No. 2, 265-274 (June 1974).

Key words: commutator subgroups; inclusion theorems; modular groups; quotient groups; solvability.

Let  $\Gamma = SL(t, Z)$ ,  $\Gamma(n)$  the principal congruence subgroup of  $\Gamma$  of level  $n$ . If  $t > 2$  it is shown that the commutator subgroup of  $\Gamma(n)/\Gamma(nm)$  is  $\Gamma(n\delta)/\Gamma(nm)$ ,  $\delta = (m, n)$ . This implies that the number of 1-dimensional representations of  $\Gamma(n)/\Gamma(nm)$  is  $\delta^{t-1}$ , and that  $\Gamma(n)/\Gamma(nm)$  is solvable if and only if each prime dividing  $m$  also divides  $n$ . Similar results are proved for  $t = 2$ , by means of inclusion theorems proved in the paper. Another noteworthy result is that if  $t > 2$ , then the commutator subgroup of  $\Gamma(n)$  is just  $\Gamma(n^2)$ .

**14195.** Abraham, B. M., Ketterson, J. B., Roach, P. R., Pfeiffer, E. R., **Demagnetization experiments on some promising new compounds for very low-temperature refrigeration**, *J. Low Temp. Phys.* **14**, Nos. 3/4, 387-396 (1974).

Key words: adiabatic magnetization; cerium compounds; cerium magnesium nitrate; low temperature thermometry; magnetic temperature; paramagnetic compounds.

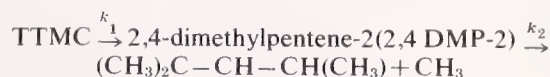
We have performed demagnetization experiments on spherical specimens of silver chloride-bonded, compacted powders of four different compounds. Pure and lanthanum-diluted cerium magnesium nitrate (CMN) was studied along with two new compounds formed from cerium iodide and antipyrine and from cerium thiocyanate and triphenyl phosphine oxide. The magnetic

temperatures  $T^*$  were determined from measurements of the magnetic susceptibility perpendicular to the axis of the initial magnetizing field. Both the lanthanum-diluted CMN and the triphenyl phosphine oxide compounds yielded significantly lower values of  $T^*$  than that obtained with CMN. The problem of thermal equilibrium within the demagnetized sample is considered.

**14196.** Tsang, W., **Thermal decomposition of 1,1,2,2-tetramethylcyclopropane in a single-pulse shock tube**, *Int. J. Chem. Kinet.* **V**, 651-662 (1973).

Key words: cyclohexene; decomposition; decyclization; shock tube; 2,4-dimethylpentene-2; 1,1,2,2-tetramethylcyclopropane.

1,1,2,2-Tetramethylcyclopropane (TTMC) has been decomposed in a single-pulse shock tube. The main reaction process is



Side reactions are unimportant. From comparative rate experiments (with cyclohexene decomposition as standard) the rate expression for these reactions are

$$k_1 = 10^{14.82} \exp(-31,320/T) \text{ sec}^{-1}$$

$$k_2 \sim 10^{16.0} \exp(-35,050/T) \text{ sec}^{-1}$$

These numbers are consistent with a "best" value for cyclohexene decomposition of

$$k(\text{C}_6\text{H}_{10} \rightarrow 1,3\text{-C}_4\text{H}_6 + \text{C}_2\text{H}_4) = 10^{15.15} \exp(33,500/T) \text{ sec}^{-1}$$

**14197.** Kuyatt, C. E., DiChio, D., Natali, S. V., **Third-order aberration coefficients of electron lenses. II**, *J. Vac. Sci. Technol.* **10**, No. 6, 1124-1126 (Nov./Dec. 1973).

Key words: aberration integrals; asymptotic trajectories; electron lens; third-order aberration coefficients.

In the standard treatments of aberration coefficients of electron lenses, deviations from perfect imagery are expressed as power series of the ray coordinates in the object and aperture planes. The resulting aberration coefficients depend on the object and aperture positions, and a complete description of the aberrations of an electron lens would require a doubly infinite set of aberration coefficients for each voltage ratio of the lens. Hawkes has carried out a general treatment of the third-order aberrations of electron lenses which is independent of object and aperture positions. Six quantities are sufficient to specify the third-order aberration properties of an electron lens. We have derived equations for these six quantities in the form of integrals, involving derivatives of the axial potential no higher than the second, and using our previously calculated potentials have computed aberration coefficients for the two-tube electrostatic lens.

**14198.** Galejs, A., Kuyatt, C. E., **Representation of focal properties of the equal-diameter two-tube electrostatic lens for computer calculations**, *J. Vac. Sci. Technol.* **10**, No. 6, 1114-1117 (Nov./Dec. 1973).

Key words: electron optics; electrostatic lenses; focal properties; lens optimization.

Previous calculations have given accurate first-order focal properties for the two-tube electrostatic lens at discrete voltage ratios. For computer optimization, calculations involving systems of two-tube lenses, one must be able to calculate the focal properties continuously over some arbitrary range of voltage ratios. Hence the data must be displayed in a continuous manner, and a method of interpolation is needed which yields functions having a high degree of smoothness. Special care must be taken to describe the lens behavior correctly near zero



strength or for the voltage ratio approaching unity. A satisfactory solution to this problem has been achieved using cubic splines. The resulting functions of the focal properties are continuous and have continuous first and second derivatives. The total beam behavior, and hence the system design, is determined by the transfer matrix which is obtained from the focal properties. To achieve sufficient accuracy in the lens calculations over the entire range of required focal properties, the region near zero lens strength had to be treated separately.

- 14199.** Tsang, W., **Recalculation of data on the thermal decomposition of 1,1-difluoroethane and 1,1,1-trifluoroethane**, *Int. J. Chem. Kinet.* **V**, 643-649 (1973).

Key words: elimination; fluoroethane; kinetics; single pulse shock tube; thermal decomposition; 1,1-difluoroethane; 1,1,1-trifluoroethane.

Disagreements in rate constants and parameters between published results on the decomposition of 1,1-difluoroethane and 1,1,1-trifluoroethane are shown to originate from incorrect specification and setting of reaction conditions in one of the studies. When corrected, applicable results are in excellent agreement.

- 14200.** Kuyatt, C. E., DiChio, D., Natali, S. V., **Focal properties of the two-tube electrostatic lens for large voltage ratios**, *J. Vac. Sci. Technol.* **10**, No. 6, 1118-1119 (Nov./Dec. 1973).

Key words: electron trajectories; focal properties; P-Q curves; two-tube electrostatic lens; ultra-focal refraction.

Previous calculations of electron trajectories and first-order focal properties of the two-tube electrostatic lens have been extended to a voltage ratio of 1000. Considerable ultrafocal refraction occurs in these strong lenses, with the result that near the highest voltage ratio studied the two focal points are both on the low-voltage side of the lens and nearly coincident. The results are presented in the form of a table and *P-Q* (image-object) curves.

- 14201.** Schweitzer, W. G., Jr., Kessler, E. G., Jr., Deslattes, R. D., Layer, H. P., Whetstone, J. R., **Description, performance, and wavelengths of iodine stabilized lasers**, *Appl. Opt.* **12**, No. 12, 2927-2938 (Dec. 1973).

Key words: iodine stabilized lasers; krypton; pressure broadening; pressure shifts; saturated absorption; wavelengths.

A description is given of lasers stabilized to components of the  $^{129}\text{I}_2$  spectrum in the region of the 633-nm laser lines for  $^3\text{He}$ - $^{20}\text{Ne}$  and  $^3\text{He}$ - $^{22}\text{Ne}$ . Relationships between operational characteristics such as power output, peak size, and peak width are shown, along with their relationships to some of the controllable parameters such as excitation level, iodine absorption, and iodine pressure. We found an iodine pressure broadening of about 13 MHz/torr with a 2.6-MHz zero-pressure intercept. The frequency shift associated with iodine pressure is roughly  $2 \times 10^{-9}$   $\nu$ /torr to the red. Power broadening and power shifts are small, about a 10 percent increase in width and about  $2 \times 10^{-11}$   $\nu$  variation in frequency for a fivefold to sixfold increase in power. These lasers exhibit a frequency stability for 10-sec sampling time of about  $2 \times 10^{-12}$   $\nu$  and a resetability of about  $1 \times 10^{-10}$   $\nu$ . The absolute vacuum wavelength for one iodine component has been measured against the  $^{86}\text{Kr}$  standard— $^3\text{He}$ - $^{20}\text{Ne}$ : $^{129}\text{I}_2$ ,  $k$   $\lambda = 632\,991.2670 \pm 0.0009$  pm. The wavelengths of several other iodine components have been determined by measuring the frequency difference between them and the  $^{129}\text{I}_2$ ,  $k$  component. Among these are  $^3\text{He}$ - $^{22}\text{Ne}$ : $^{129}\text{I}_2$ ,  $B$   $\lambda = 632\,990.0742 \pm 0.0009$  pm; and  $^3\text{He}$ - $^{20}\text{Ne}$ : $^{127}\text{I}_2$ ,  $i$   $\lambda = 632\,991.3954 \pm 0.0009$  pm. These results were obtained using the Rowley-Hamon model for asymmetry in the krypton line and assume that the defined value for the standard is associated with the center of

gravity of the line profile. The indicated uncertainties are statistical. No allowance has been included for imperfect realization of the krypton standard or for uncertainty in the asymmetry model.

- 14202.** Waterstrat, R. M., van Reuth, E. C., **Effects of compositional variations on the atomic ordering in Al<sub>5</sub> phases**, (Proc. 3d Bolton Landing Conf. on Ordered Alloys, Lake George, N. Y., Sept. 8, 1969), Chapter in *Ordered Alloys, Structural Application and Physical Metallurgy*, pp. 95-110 (Claitor's Publ. Div., Baton Rouge, La., 1970).

Key words: A-elements; A-site atoms; band structure; B-elements; d-electron; electron-compound; wave-functions.

Binary Al<sub>5</sub> phases containing only transition elements have been found to possess composition ranges which shift in a regular manner consistent with periodic table positions. This is suggestive of the so-called "electron-compound" behavior previously noted for the sigma phases and other complex structures. It has been shown that deviations from the "ideal" (A<sub>3</sub>B) composition are accomplished by direct substitution of A-elements and B-elements rather than by vacancy formation. The degree of long-range atomic ordering decreases as one selects elements closer to the manganese column in the periodic table. This effect may be related to the extent of overlapping for d-electron wave-functions particularly along the chains of A-site atoms and is consistent with the band structure model proposed by Labbé and Friedel.

- 14203.** Arnett, R. W., Voth, R. O., **A computer program for the calculation of thermal stratification and self-pressurization in a liquid hydrogen tank**, *NASA CR-2026*, 131 pages (National Aeronautics and Space Administration, Washington, D.C., May 1972).

Key words: computer program; cryogenic; liquid hydrogen; mathematical model; self pressurization; thermal stratification.

This report describes an analysis and computer program used to calculate the thermal stratification and the associated self pressurization of a closed liquid hydrogen tank. A sample calculation is provided as well as a description and listing of the program. Fortran-IV language is used and runs have been made on IBM 360/65 and CDC 3600 computers. Comparisons are made between the program calculations and test results from both ground and orbital coast tests of a Centaur space vehicle.

- 14204.** Stiehler, R. D., **Standards and standardization**, *Am. Soc. Testing Mater. Spec. Tech. Publ.* **553**, 87-103 (1974).

Key words: interlaboratory testing; international standards; standardization; standards.

Standards are practices established by authority, custom, or common consent. The practices embrace all activities of society including social, religious educational, and technical practices. This paper deals with technical practices embodied in national or international engineering standards. A good engineering standard should: (1) stimulate competition and not restrict trade; (2) prescribe practices which conserve natural resources; (3) be abreast of technology and not be a deterrent to desirable change arising from new knowledge, new capabilities, or new environment; (4) be concise, explicit, and limited to essential provisions and requirements; and (5) be effective in achieving its purpose.

Due to the rapid increase in the number of standards both domestically and internationally, there is a movement to control proliferation through the development and use of international standards, primarily under the aegis of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). Standards developed by ISO and IEC have now become sufficient in number to be a significant factor in international trade.



Standards development has varied considerably from one industry to another, and U.S. participation in ISO and IEC has also varied from industry to industry. ISO Technical Committee 45 on Rubber and Rubber Products has been among the ten most active committees, and U.S. participation has been exceptionally effective in it. Nearly 80 percent of the 102 standards developed by ISO/TC 45 through 1972 are in accord with ASTM Standards.

Recently, there has been a growing interest in standards for consumer products, both nationally and internationally. Eight of the 20 ISO committees most recently established deal with consumer products. There has also been a growing interest in ascertaining the ability of laboratories to obtain consistent results using standard methods, both nationally and internationally. The Standard Reference Materials issued by NBS and the NBS interlaboratory programs for testing were established for this purpose. Laboratory performance, international standardization, and the development of standards for consumer products are likely to become increasingly important in future standardization efforts.

- 14205.** Wagman, D. D., Jobe, T. L., Domalski, E. S., Schumm, R. H., **Temperatures, pressures, and heats of transition, fusion and vaporization**, Chapter 4j in *American Institute of Physics Handbook, Third Edition*, D. E. Gray, Ed., pages 4-222–4-261 (McGraw-Hill Book Co., New York, N.Y. 1972).

Key words: fusion heat; fusion temperature; transition heat; transition temperature; vaporization heat; vaporization temperature.

Summary of values of temperatures, pressures and heats of phase change for a selected set of inorganic and organic substances. Data for over 500 compounds are tabulated, including all elements for which thermodynamic information is available, halides, oxides, and some sulfates, nitrates, etc.

- 14206.** Haber, S., Shisha, O., **Improper integrals, simple integrals, and numerical quadrature**, *J. Approximation Theory* **11**, No. 1, 1-15 (May 1974).

Key words: improper integrals; integration; numerical integration; quadrature; Riemann integrals.

The question of the convergence of numerical integration formulas (of Riemann sum type) to the improper Riemann integral  $\int_0^\infty f(x)dx$  is studied. A new integral over  $[0, \infty)$ , more restrictive than the improper Riemann integral but not absolutely convergent, is introduced. Necessary and sufficient conditions are found for a function to be integrable in the new sense; they are stated in terms of property of functions similar to the property of being of bounded variation. A convergence theorem for the numerical integration of such functions is given, and also weaker convergence theorems for the integration of improperly Riemann-integrable functions.

- 14207.** Christ, B. W., Picklesimer, M. L., **The relationship between Luder's strain, testing system compliance and other phenomenological variables affecting serrated yielding of recrystallized iron**, *Acta Met.* **22**, 435-447 (Apr. 1974).

Key words: compliance; Luder's strain; recrystallized iron; serrated yielding; tensile test.

Constant cross-head speed uniaxial tensile tests were conducted on recrystallized iron wires (0.0016 m diameter) which exhibited serrated yielding as a single Luder's band front advanced intermittently from one grip to the other. The ranges of temperature and cross-head speed were, respectively, 383 and 508 K and  $8.3 \times 10^{-7}$ – $8.3 \times 10^{-6}$  m/s. Average load drop amplitude,  $\Delta L$ , was about 25 percent of the peak stress.

The effect of testing system compliance,  $C$ , on the number of equal load drops,  $n$ , during serrated yielding was determined. It was found that the number of load drops decreased as compliance increased. The following relationships for average Luder's band front advance during a single load drop was established,

$$\bar{a}_i = l_0/n$$

where  $l_0$  = gage length. Furthermore, it was demonstrated that average Luder's strain during the  $i$ th load drop,  $\epsilon_i$ , is given by

$$\epsilon_i = C_i \Delta L_i / \bar{a}_i = n C_i \Delta L_i / l_0.$$

It was concluded that analysis of the  $i$ th load drop is a valuable new method for studying Luder's strain during serrated yielding.

- 14208.** Cali, J. P., **An idea whose time has come** (guest editorial), *Clin. Chem.* **19**, 291-293 (1973).

Key words: accuracy; clinical chemistry; health.

An editorial stressing the importance of achieving accuracy in the methods used in clinical chemistry. Meaningful measurement systems have five requirements: (1) agreement on a rational system of base units; (2) well-characterized materials (e.g., NBS-SRM's) that together with (3) referee methods of proven accuracy are used to realize these units and their derivatives; (4) field methods used in practical application to be tested for accuracy by (2) and (3); and, (5) a quality control assurance program to insure the long-term integrity of the measurement system.

Actions initiated and completed within the past 3 years are stated showing that the achievement of accuracy in clinical chemistry is underway. A plea for an acceleration of this process is made.

- 14209.** Cali, J. P., **Problems of standardization in clinical chemistry**, *Bull. Wld. Hlth. Org.* **48**, 721-726 (1973).

Key words: accuracy; analysis; clinical chemistry; measurement; precision; referee methods; specificity; standard reference materials.

If analytical results in clinical chemistry are to be made meaningful, i.e., accurate, precise, and specific, a systematic approach to their attainment is necessary. Furthermore, because this system is so complex in scope and the need for it is so widespread, it will require international coordination. Agreement on the units of measurement, the production and certification of standard reference materials, and the development of reference methods of demonstrated accuracy will require the support of all segments of clinical chemistry.

- 14210.** Cali, J. P., **A systematic approach to accuracy in clinical chemistry**, *Med. Instrum.* **8**, No. 1, 17-21 (1974).

Key words: accuracy; clinical chemistry; meaningful measurement.

When measurements made in clinical chemistry laboratories are "meaningful," the values obtained are accurate, precise, and specific. The latter two characteristics, related to reproducibility and singularity respectively, represent no great problem in clinical chemistry measurements. Accuracy, however, which is related to the "true" value, remains a somewhat elusive goal. Unless a measurement system is based on accuracy, comparison of results obtained over time and distance in different laboratories may lead to doubtful or misleading conclusions. A meaningful measurement system consists of five parts: (1) a rational, self-consistent, agreed-on system of units of measurement; (2) well characterized materials used in conjunction with; (3) referee methods of known accuracy to realize in practice the base units and their derivative; (4) field or applied methods of measurement, assessed for accuracy via parts 2 and 3; and (5) a process whereby the long-term integrity of the measurement system is assured.



**14211.** Beatty, R. W., **A frequently reinvented circuit (abstract)**, *IEEE Trans. Microwave Theory Tech. Letter to Editor MTT-22*, No. 5, 58 (May 1974).

Key words: directional couplers; impedance measurement.

Attention is called to published work describing an impedance-measuring circuit that is frequently reinvented.

**14212.** Arora, V. K., Peterson, R. L., **Theory of magnetophonon structure in the longitudinal magnetothermal emf**, *Phys. Rev. B* **9**, No. 10, 4323-4328 (May 15, 1974).

Key words: magnetophonon effect; Seebeck effect; semiconductor; transport.

The magnetophonon effect, as manifested in the longitudinal magnetothermal emf (Seebeck coefficient  $Q_{zz}$ ), is examined analytically and numerically in the limit of no Landau-level broadening, for combined optic and acoustic-phonon scattering of electrons in nonpolar semiconductors. In addition to off-resonance maxima occurring at magnetic fields somewhat larger than those given by the Gurevich-Firsov resonance condition  $N\omega_c = \omega_0$ ,  $N=1,2,\dots$ , where  $\omega_c$  and  $\omega_0$  are the cyclotron and optic-phonon frequencies, discontinuities in the derivative of  $Q_{zz}$  with respect to magnetic field are found. The slope discontinuities lie precisely at  $N\omega_c = \omega_0$  and at  $(2n+1)\omega_c = 2\omega_0$ ,  $n=0,1,\dots$ , yielding additional structure characterized by  $\partial|Q_{zz}|/\partial B_- > \partial|Q_{zz}|/\partial B_+$  at all temperatures and degrees of elastic scattering.

**14213.** Unassigned.

**14214.** Cezairliyan, A., **A high-speed (subsecond) system for accurate thermophysical measurements at high temperatures**, (Paper 73-743, Proc. AIAA 8th Thermophysics Conf., Palm Springs, Calif., July 16-18, 1973), Chapter in *Thermophysics and Spacecraft Thermal Control* **35**, 205-228 (MIT Press, Cambridge, Mass., 1974).

Key words: electrical resistivity; emittance; heat capacity; high-speed measurements; high temperatures; thermophysics.

A system is described for the high-speed (subsecond) accurate measurement of selected thermophysical and related properties of electrically conducting substances in the temperature range 1500 K to the melting point of the specimen. The method is based on rapid resistive self-heating of the specimen from room temperature to any desired high temperature in less than 1 sec by the passage of electrical currents through it and on measuring and recording the experimental quantities every 0.4 msec with a full-scale signal resolution of one part in 8000. The system has been used to measure heat capacity, electrical resistivity, hemispherical total emittance, normal spectral emittance, and the melting point of niobium, molybdenum, tantalum, tungsten, some refractory alloys, and graphite. The results of preliminary experiments have shown the potential application of the system to measurements of temperatures and energies of solid-solid phase transformations, heat of fusion, and thermal expansion at high temperatures.

**14215.** Clark, A. F., Hust, J. G., **A review of the compatibility of structural materials with oxygen**, *AIAA J.* **12**, No. 4, 441-454 (Apr. 1974).

Key words: compatibility; materials; metals; oxygen; safety; survey.

The compatibility of structural materials, particularly metals, with gaseous and liquid oxygen is reviewed. Various methods of testing for oxygen compatibility are described. The literature is reviewed with respect to accidents, experimental measurements of ignition and combustion, the effect of high pressure, theory, and properties data. The relative compatibility of various materials is discussed and a selection procedure recommended. Needed future research is also outlined.

**14216.** Coble, J. B., Achenbach, P. R., **Description of equipment and instrumentation for a field study of a total energy system in an apartment development**, *Proc. 7th Intersociety Energy Conversion Engineering Conf., San Diego, Calif., Sept. 25-29, 1972*, pp. 1-27 (Sept. 1972).

Key words: data acquisition system; electrical power system; energy conservation; fuel utilization; thermal efficiency; thermal energy system; total energy system; utility system performance; waste heat recovery.

The Department of Housing and Urban Development selected the BREAKTHROUGH site at Jersey City, N.J. as the location for an installation and field study of a total energy system. This development covers six acres, and is comprised of four buildings containing 488 dwelling units, a small building for commercial use, two small schools, a swimming pool, and the total energy plant. The field study of this installation is being carried out by the National Bureau of Standards to produce much-needed authoritative information on engineering performance, maintenance requirements, and load-and-cost data for total energy systems.

The central plant and the individual buildings are being extensively instrumented to provide digital data on fuel utilization, the generation of electrical and thermal energy, the excess heat rejected, and the utilization of electrical and thermal energy by all major segments of the load. A separate analog data system is being employed to obtain recordings of transient conditions of voltage, frequency, current, power factor, and load division during sudden load changes and to record interruptions of service due to overload or malfunction of equipment. The environmental impact of the total energy plant with respect to noise, vibration, air pollution, and aesthetics is also being evaluated.

**14217.** Gallagher, A. C., York, G., **A photoionization source of monoenergetic electrons**, *Rev. Sci. Instrum.* **45**, No. 5, 662-668 (May 1974).

Key words: monochromatic electrons; photoionization source.

A photoionization source of monoenergetic electrons is described and design criteria for such sources are discussed. The present design produces a beam of  $\approx 10^{-12}$ - $10^{-13}$  A by photoionization of a metastable ( $^1D_2$ ) barium beam inside the cavity of a He-Cd laser operating at 3250 Å. The photoelectrons are produced with 17 MeV kinetic energy and a calculated energy spread of  $< 1$  MeV. Energy analysis is provided by measuring the width of the 11.08 eV argon resonance. The observed width of this resonance has, to date, been limited to  $\sim 6$  MeV, but tests are reported which indicate that this width is largely due to Doppler spreading in the target atomic beam and potential gradients across the collision volume.

**14218.** Heinrich, K. F. J., Rasberry, S. D., **X-ray fluorescence analysis of high-temperature superalloys—calibration and standards**, Chapter in *Advances in X-Ray Analysis*, C. L. Grant, C. S. Barrett, J. B. Newkirk, and C. O. Ruud, Eds. **17**, 309-317 (Plenum Publ. Corp., New York, N.Y., June 1974).

Key words: calibration; empirical calibration; high-temperature superalloys; x-ray fluorescence; x-ray spectrochemical analysis.

The current experimental work extends our calibration concept of separating the effects of absorption and fluorescence to the high-temperature superalloys. The new calibration procedure produces calibration equations which are valid over wide ranges of composition—a feature which is useful in the analysis of high-temperature superalloys. For the specimens considered, the elements iron, nickel, chromium, cobalt and molybdenum can be present at levels greater than 10 percent; while tantalum, aluminum, titanium, manganese, silicon and vanadium may be



present at levels between 1 and 6 percent. The calibration for this group of alloys has required, in the past, a large number of standards; the number is reduced by judicious application of the given correction equations. Analytical errors can be limited to 1 to 2 percent in the use of this method.

- 14219.** Hosteny, R. P., Hinds, A. R., Wahl, A. C., Krauss, M., **MC SCF calculations on the lowest triplet state of  $\text{H}_2\text{O}$** , *Chem. Phys. Letters* **23**, No. 1, 9-12 (Nov. 1, 1973).

Key words: electron impact; energy loss; energy surface; excitation energy;  $\text{H}_2\text{O}$ ; repulsive curve; triplet state.

Recent electron impact work on  $\text{H}_2\text{O}$  has shown a broad absorption peak near 4.5 eV which has generally been attributed to the lowest triplet ( $^3\text{B}_1$ ) state of  $\text{H}_2\text{O}$ . However, the results of SCF and multiconfiguration SCF (MC SCF) calculations reported here indicate that the  $^3\text{B}_1$  state is unbound with respect to the dissociative asymptotes  $\text{H}(^2\text{S}) + \text{OH}(^2\Pi)$  and  $\text{O}(^3\text{P}) + \text{H}_2(^1\Sigma_g^+)$ , in disagreement with the experimental interpretation.

- 14220.** Newman, M., **Units in arithmetic progression in an algebraic number field**, *Proc. Am. Mathematical Soc.* **43**, No. 2, 266-268 (Apr. 1974).

Key words: algebraic number fields; units.

It is shown that a given algebraic number field of degree  $n \geq 4$  over the rationals can contain at most  $n$  units in arithmetic progression, and that this bound is sharp.

- 14221.** Achenbach, P. R., Coble, J. B., **Site analysis for the application of total energy systems to housing developments**, *Proc. 7th Intersociety Energy Conversion Engineering Conf., San Diego, Calif., Sept. 25-29, 1972*, pp. 1-31 (Sept. 1972).

Key words: air conditioning; air pollution; central utility systems; electric power generation; energy conservation; energy costs; heat recovery, power systems; total energy systems; utilities for housing.

In early 1970 the Department of Housing and Urban Development approved a program to design and construct about 2800 dwelling units on eleven sites in the United States with the objective of encouraging the industrialization of the home-building process. It was also decided that as a part of this program, Operation BREAKTHROUGH, a full-scale field study would be made to determine whether or not total energy systems could provide economical and reliable energy services to apartment complexes and maintain a high level of environmental quality.

The characteristics of the eleven sites that were important in determining their suitability for a total energy system were studied by the National Bureau of Standards as a basis for selection. Fourteen parameters related to site planning, climate, building design, load factors, cost for fuel, equipment and maintenance, and the interest of the builders and developers were investigated in the feasibility study. The study resulted in the choice of Jersey City, New Jersey as the preferred location for the pilot installation of a total energy system and the identification of three other sites of lower priority.

- 14222.** Ball, J. J., **Device for stabilizing electrodeless discharge lamps**, *Rev. Sci. Instrum.* **44**, No. 8, 1141 (Aug. 1973).

Key words: atomic spectroscopy; electrodeless lamps.

Increased stability for electrodeless discharge lamps used in atomic spectroscopy is attained by mounting a heater coil below the lamp. Heating by convection maintains the lamp at a constant temperature resulting in stable output within 2 percent.

- 14223.** Blackburn, D. L., Schafft, H. A., Swartzendruber, L. J., **Nondestructive photovoltaic technique for the measurement of resistivity gradients in circular semiconductor wafers**, *J. Electrochem. Soc.* **119**, No. 12, 1773-1778 (Dec. 1972).

Key words: germanium; inhomogeneities; measurement methods; photovoltaic effect; resistivity; semiconductors; silicon.

The bulk photovoltaic effect is applied to the measurement of radial resistivity gradients in circular semiconductor wafers. This nondestructive technique permits a continuous measurement of the resistivity variation to be made by contacting only the rim of the wafer. An expression relating the radial resistivity gradient to the photovoltage measured at the wafer rim is derived and used to calculate the resistivity profile. Photovoltaic resistivity profiles, which were made on silicon and germanium wafers with resistivities ranging from  $1 \Omega \cdot \text{cm}$  to  $5000 \Omega \cdot \text{cm}$ , generally agree well with two- and four-probe resistivity profiles in the central portion of the wafer. Lack of agreement observed at positions in the outer half of the wafer is discussed in terms of basic material parameters, electrical contact quality, and measurement precision of the four-probe method.

- 14224.** Perloff, A., **Quartz analysis by x-ray diffraction**, *Proc. Roundtable Discussion on Analytical Techniques for Quartz, Amer. Conf. Governmental Industrial Hygienists, Cincinnati, Ohio, Dec. 6-7, 1972*, pp. 1b-6b (1973).

Key words: microanalysis by x-ray diffraction; quartz dust.

Standard x-ray diffraction techniques can be readily used to measure small quantities of respirable-sized quartz dust. Under idealized circumstances a practical lower limit of detection is  $20 \mu\text{g}$  of quartz within  $\pm 5 \mu\text{g}$ . No significant difference between x-ray units of different manufacturers was observed.

- 14225.** Brown, D. W., Lowry, R. E., Wall, L. A., **Radiation-induced polymerization at high pressure of 2,3,3,3-tetrafluoropropene in bulk and with tetrafluoroethylene**, *J. Polymer Sci.* **9**, Part A-1, 1999-2007 (1971).

Key words: polymerizing material; propene; radiation-induced polymerization; tetrafluoroethylene; tetrafluoropropene.

The radiation-induced polymerization of 2,3,3,3-tetrafluoropropene was studied as a function of temperature ( $22-100^\circ\text{C}$ ) and pressure (autogenous to  $10^4 \text{ atm}$ ). Rates have varied 100-fold for the same reaction conditions probably because of trace impurities. The most rapidly polymerizing material has a rate of 4.5 percent/hr at 6000 atm,  $22^\circ\text{C}$ , and 1500 rad/hr. The activation enthalpy and volume are 4 kcal/mole and  $-13 \text{ cc/mole}$ , respectively. Rates are proportional to the square root of the radiation intensity. Degrees of polymerization varied between  $2 \times 10^3$  and  $2 \times 10^6$ . In copolymerization with tetrafluoroethylene the reactivity ratios at  $22^\circ\text{C}$  and 5000 atm are 0.37 (the ratio for addition to the tetrafluoroethylene-ended radical) and 5.4 (the ratio for addition to the tetrafluoropropene-ended radical). Comparison of ratios for the copolymerization of other fluorine-containing monomers with tetrafluoroethylene shows that they generally disfavor incorporation of the latter.

- 14226.** Buehler, M. G., **Thermally stimulated measurements: The characterization of defects in silicon  $p$ - $n$  junctions**, *Semiconductor Silicon*, pp. 549-560 (1973).

Key words: defect centers;  $p$ - $n$  junction; semiconductor characterization; silicon; thermally stimulated measurements.

Thermally stimulated capacitance and current measurements utilize the ability of defects in the vicinity of a  $p$ - $n$  junction to trap holes or electrons and to emit them after receiving sufficient thermal energy. Values for defect densities, energy levels, and emission rates can be derived from these measurements where the limit of detectability can be as low as  $10^{10} \text{ defects/cm}^3$ . From these values the atomic nature of the defects can be identified.



**14227.** Benjamin, I. A., Parker, W. J., **Fire spread potential of ABS plastic plumbing**, *Fire Technol.* **8**, No. 2, 104-119 (May 1972).

Key words: ABS; building fires; drain pipe; fire spread; pipe chase; smoke; temperature; vent pipe; waste pipe.

Eight chases, each with a different drain, waste, and vent pipe installation, were subjected to the standard ASTM E119 fire exposure for up to 2 hours duration. These tests were designed to examine the possibility of vertical fire spread from one room to another via a chase containing ABS pipes and fittings; and to identify the type of installation least susceptible to fire spread.

The best performance should be obtained when the ABS lateral enters the smoke-tight chase at a downward angle of  $45^\circ$  and is enclosed in a steel sleeve at the point of penetration of the chase wall.

**14228.** Benjamin, I. A., **The criteria for fire safety in Operation BREAKTHROUGH**, *Bldg. Stand.* **40**, No. 6, 32-36 (Nov.-Dec. 1971).

Key words: fire resistance; fire safety; housing performance; life safety.

The presentation gives the philosophical background for some of the criteria which have been used for evaluation of innovative housing in Operation BREAKTHROUGH. Particular attention is given to a modified concept of fire resistance, the introduction of new types of material controls and the concept of life safety system for residential construction.

**14229.** Benjamin, I. A., **The influence of fire-resistant design on survival**, *Proc. Symp. Designing to Survive Disaster*, Illinois Institute of Technology Research Institute, Chicago, Ill., Nov. 6-8, 1973, pp. 263-282 (1973).

Key words: building fires; design; evacuation; fire alarms; fire protection; fire resistance; fire safety; fire spread; fire statistics; fire suppression; high rise buildings; ignition source; life safety; refuge areas; smoke control.

Annual fire losses in the U.S. approximate 12,000 deaths and over \$2 billion direct property damage. New materials and new methods of construction have produced new potential fire hazards which increase the threat to life, especially in tall, densely-populated buildings. Data are presented showing the most common ignition sources for building fires. Fire safety must be included at the earliest stages of building design, in order to assure that it is systematic and adequate to protect lives. Several methods of dealing with the fire problem are described, including prevention of ignition, containment of fire and smoke within a limited space, automatic and manual methods of fighting fire, and provisions for life safety. Smoke often causes death before flames and heat reach the building occupants and, therefore, engineered smoke control design measures must be a major provision to protect lives. Problems with total evacuation of high rise and institutional buildings are described, and new life safety concepts, such as refuge areas, are suggested as alternatives. As buildings become more complex and hazardous construction materials become more prevalent, it is increasingly important to design ahead for fire prevention so that protection is in the building when it is built, not as an afterthought.

**14230.** Blevin, W. R., Geist, J., **Influence of black coatings on pyroelectric detectors**, *Appl. Opt.* **13**, No. 5, 1171-1178 (May 1974).

Key words: black coatings; detectors; gold-black; pyroelectric; radiometry.

The extent to which the thermal capacitance and resistance of a black coating on a pyroelectric detector offset the gain in optical absorptance is investigated. A black paint is shown to be of little value, but a coating of gold-black may increase the detector

responsivity for modulation frequencies up to at least several kilohertz. When a coated pyroelectric detector is calibrated electrically, a correction is necessary for the thermal impedance of the black. For gold-blacks of superficial density  $2 \text{ g m}^{-2}$ , this correction is shown to be less than 2 percent for frequencies within the 0-100-Hz range.

**14231.** Cuthill, J. R., McAlister, A. J., Erickson, N. E., Watson, R. E., **X-ray photoemission studies of rare earth hard magnets**, (Proc. 19th AIP Conf. on Magnetism and Magnetic Materials, Boston, Mass., Nov. 13-16, 1973), Chapter in *Magnetism and Magnetic Materials*, C. D. Graham, Jr., and J. J. Rhyne, Eds., pp. 1039-1043 (American Institute of Physics, New York, N. Y., 1974).

Key words: electronic structure; ESCA; hard magnets; magnetic materials; photoelectron spectroscopy; rare-earth magnets; x-ray photoelectron.

In the present investigation we attempt to probe the electronic properties of the  $\text{RCO}_5$  compounds by x-ray photoelectron spectroscopy studies of  $\text{SmCo}_5$  and  $\text{PrCo}_5$  and endeavor to relate the results to the properties of the pure metals and to the picture developed to describe the magnetism of the compounds. The results indicate a valence band structure which is similar to that of Co metal; there is the suggestion that if there is charge flow it is off the rare-earth sites; there appears to be significant change in the 4f spectra from that of the pure rare-earth metals; and there is a suggestion of f-d hybridization.

**14232.** Deslattes, R. D., Henins, A., **X-ray to visible wavelength ratios**, *Phys. Rev. Lett.* **31**, No. 16, 972-975 (Oct. 15, 1973).

Key words: conversion factor; interferometer; lattice repeat distance; x-ray; wavelength.

The lattice repeat distance of a nearly perfect single crystal of silicon has been measured in terms of the visible wavelength of a stabilized He-Ne laser. This crystal subsequently has been used to diffract reference x-ray lines ( $\text{Cu } K\alpha_1$ ,  $\text{Mo } K\alpha_1$ ) thereby establishing their wavelength relative to visible standards. In terms of the x-ray scale in which  $\lambda(\text{Cu } K\alpha_1) = 1.537400 \text{ kxu}$ , the conversion factor is  $\Lambda_{\text{Cu}} = 1.0020802 \text{ \AA/kxu}$  (1 ppm); if  $\lambda(\text{Mo } K\alpha_1) = 0.707831 \text{ kxu}$ ,  $\Lambda_{\text{Mo}} = 1.0021017 \text{ \AA/kxu}$  (0.6 ppm).

**14233.** Gadzuk, J. W., **Chemisorption bond geometry determined by photoemission (Abstract)**, *J. Vac. Sci. Technol.* **11**, No. 1, 275 (Jan./Feb. 1974).

Key words: angular distributions; chemisorption; photoemission; photoionization; surfaces.

In this paper it is shown how a measurement of the angular distribution of electrons which are photoemitted from atoms chemisorbed on a metal surface can be used to determine the chemisorption bonding geometry.

**14234.** Haynes, W. M., **Viscosity of saturated liquid methane**, *Physica* **70**, No. 2, 410-412 (Dec. 1973).

Key words: comparisons; graph; methane; saturated liquid; table; torsional crystal; viscosity.

The results of absolute measurements of the viscosity of saturated liquid methane using a torsionally vibrating quartz crystal are reported for temperatures from 95 to 190 K. Comparisons are made with other data, all of which have been obtained with techniques different from that of the present work.

**14235.** Hein, R. A., Cox, J. E., Blaughner, R. D., Waterstrat, R. M., van Reuth, E. C., **Low-temperature annealing effects upon the superconducting properties of  $\text{V}_3\text{Au}$** , *Physica* **55**, 523-533 (1971).

Key words: annealing; magnetic field; stoichiometry; superconductivity; transition temperature.



The superconducting transition temperature,  $T_0$ , and the initial slope of the upper critical magnetic field curve of  $V_3Au$  have been measured as functions of low (400-800 °C) temperature annealing.  $T_0$  ranges from no superconductivity down to 0.015 K to a  $T_0$  as high as 3.22 K. X-ray diffractometer data indicated that all the samples employed in this study had the Al<sub>5</sub> structure. Metallographic studies indicated the presence of a few percent of a second Au rich phase in these equilibrated samples. The x-ray data also indicated that the low-temperature anneals did change the degree of crystallographic long range order present in the samples and our data clearly indicate that  $T_0$  increases quite markedly as the Bragg-Williams long-range order parameter approaches the value of unity. The magnitude of the initial slope of the critical magnetic field curve also increases with increase in  $T_0$  (from  $-22 \times 10^3$  Oe/deg to  $-37 \times 10^3$  Oe/deg for  $T_0 = 0.89$  K and 3.1 K respectively) with one notable exception, and that is the sample with the highest  $T_0$  for which the slope has its smallest value, namely  $-16 \times 10^3$  Oe/deg.

**14236.** Heinrich, K. F. J., **Electron and ion probe microanalysis—physical bases**, (Proc. Symp. on Microprobe Analysis as Applied to Cells and Tissues, Seattle, Wash., Apr. 29-May 2, 1973), Chapter in *Microprobe Analysis as Applied to Cells and Tissues*, pp. 75-87 (June 1974).

Key words: biological analysis; electron probe; ion probe; microprobe analysis; quantitation; soft tissue.

Both electron and ion probe analysis are tools for the detection and measurement of elements on a micrometer ( $\mu\text{m}$ ) scale. The physical bases of electron probe microanalysis are now reasonably well known, but the special conditions prevalent in the analysis of biological tissue present specific difficulties. New data evaluation procedures, such as the Monte-Carlo computation technique, may be useful to attack these problems.

The ion probe is a novel tool of great promise for the analysis of biological tissue since it combines shallow sampling with very high sensitivity and capability for the analysis of elements of low atomic number.

**14237.** Jacox, M. E., Milligan, D. E., **Matrix isolation study of the vacuum ultraviolet photolysis of allene and methylacetylene vibrational and electronic spectra of the species  $C_3$ ,  $C_3H$ ,  $C_3H_2$ , and  $C_3H_3$** , *Chem. Phys.* **4**, 45-61 (1974).

Key words: allene;  $C_3H_n$  ( $n = 0$  to 3); infrared spectrum; isotopic substitution; matrix isolation; methylacetylene; ultraviolet spectrum; vacuum-ultraviolet photolysis.

Upon hydrogen-discharge photolysis of normal or deuterium-substituted allene or methylacetylene in an argon or a nitrogen matrix at 14 K, infrared absorptions of all of the  $C_3H_n$  species with  $n < 4$  appear. A hydrogen-deformation fundamental of  $C_3H_2$  has been identified in the far infrared. Infrared studies of the partially deuterium-substituted methylacetylenes indicate that extensive photoisomerization occurs. The observed products are consistent with those predicted using the previously postulated gas-phase photolysis mechanism. The ultraviolet spectrum of  $C_3H_3$  corresponds closely with that characteristic of the gas-phase molecule. Comparison of the spectrum between 1900 and 4000 Å of photolyzed methylacetylene with that of matrix-isolated graphite vapor has indicated that any new electronic transition of  $C_3$  in this region must be weak.

**14238.** Kraft, R., **Uniqueness and existence for the integral equation of interreflections**, *SIAM J. Math. Anal.* **5**, No. 2, 293-302 (Apr. 1974).

Key words: contractivity; existence of solutions; integral equations; interreflections; radiation transfer; uniqueness of solutions.

The integral equation of interreflections, determining radiant energy exchange in cavities, is shown to have a unique solution

in the space on nonnegative functions defined over the cavity surface. The result is established by employing the contraction mapping principle.

**14239.** LaVilla, R. E.,  **$M_{4,5}$  emission spectra from  $Gd_2O_3$  and  $Yb_2O_3$** , *Phys. Rev. A* **9**, No. 5, 1801-1805 (May 1974).

Key words:  $Gd_2O_3$ ; fluorescence spectra;  $M_{4,5}$  emission spectra; resonance radiation;  $Yb_2O_3$ .

The  $M_{4,5}$  emission spectra from  $Gd_2O_3$  and  $Yb_2O_3$  have been obtained in fluorescence on a double-crystal spectrometer. The profiles differ from the  $M_{4,5}$  emission spectra excited by electron impact. These differences are due to resonance radiation and substantiate the interpretation given by Bonnelle and Karnatak. The  $M\alpha$  emission line was found to lie above (in energy) the  $M_{5-}$  absorption resonance line  $Yb_2O_3$ , which is in contrast to  $Gd_2O_3$  and general experience. It is suggested that this observation is a result of the discrete nature of the absorption lines. With the help of estimated binding energies for the final configurations  $5p^5_{1/2,3/2}4f^7$ , the photoelectron spectrum of  $Gd_2O_3$  is discussed.

**14240.** Levy, J., **The optimal size of a storage facility**, *Nav. Res. Log. Quart.* **21**, No. 2, 319-326 (June 1974).

Key words: building design; inventory theory.

The appropriate size for a piece of fixed capital equipment (measured in units of capacity) depends on the anticipated demand for its services and on its cost. Using several models developed in the study of optimal inventory policy we derive the contribution to cost reduction that additional storage space makes under each of these models. Comparison of the sum of the discounted benefits (i.e., reduced operating cost) with construction costs for additional storage space then yields the optimal size of the storage facility.

**14241.** Milligan, D. E., Jacox, M. E., **Spectra of free radicals and molecular ions produced by vacuum ultraviolet photolysis in low-temperature matrices**, (Proc. Advanced Study Institute, NATO, Valmorin, Quebec, Canada, Aug. 5-17, 1973), Chapter in *Chemical Spectroscopy and Photochemistry in the Vacuum-Ultraviolet* **8**, Ser. C, 305-315 (D. Reidel Publ. Co., Boston, Mass., 1974).

Key words: free radicals;  $HAr_n^+$ ; infrared spectrum; molecular ions;  $NO_2^-$ ; reaction of OH with CO; ultraviolet spectrum; vacuum-ultraviolet photolysis of HCN, of halogen cyanides, of  $CH_4$ , of  $CH_3Cl$ , of  $CH_3OH$ , of  $C_2H_2$ , of  $HCCl_3$ .

The principles governing the stabilization of small free radicals and molecular ions in inert, rigid matrices will be reviewed. Emphasis will be placed on the strengths and limitations of the technique in obtaining information of concern to the photochemist. Examples will be drawn from studies of the vacuum-ultraviolet photolysis of HCN,  $CH_4$ ,  $CH_3Cl$ ,  $CH_3OH$ ,  $C_2H_2$ ,  $NO_2$ , and  $HCCl_3$  in a matrix environment.

**14242.** Block, S., Piermarini, G. J., **The melting curve of sulfur to 300 °C and 12 kbar**, *High Temp.-High Pressures* **5**, 567-573 (1973).

Key words: diamond-anvil cell; high pressure; melting curve; polymorphism; sulfur.

The melting curve of sulfur has been studied to 300 °C and 12 kbar using a diamond-anvil high-pressure cell and an optical system which utilizes the ruby-fluorescence  $R_1$  line shift for measuring the pressure. Two triple points were determined in this temperature range: (i) L-IV-VI at  $(235 \pm 5)^\circ\text{C}$  and  $(8.5 \pm 1)$  kbar, and (ii) L-VI-VIII at  $(290 \pm 5)^\circ\text{C}$  and  $(12 \pm 5)$  kbar. Because of the nonequilibrium behavior of sulfur the melting curve could not be characterized with any degree of certainty above 235 °C.



14243. Unassigned.

14244. Carpenter, B. S., **Lithium determination by the nuclear track technique**, (Proc. Int. Conf. Modern Trends in Activation Analysis, Saclay, France, Oct. 1-6, 1972), *J. Radioanal. Chem.* **19**, 233-234 (1974).

Key words: alpha tracks; biological material; image analyzing system; lithium; microscope; nuclear track technique; standard reference material.

The Nuclear Track Technique was used to determine lithium in Biological Standard Reference Material 1571 (Orchard Leaves). Alpha tracks produced in cellulose acetate (CA) from the nuclear reaction  ${}^6\text{Li}(n,\alpha){}^3\text{H}$  with thermal neutrons were counted to determine the concentration of lithium present. The method of standard additions was used and, with least squares analysis of the data, the lithium concentration was found to be  $13.72 \pm 1.50$  ppm.

14245. Cassel, J. M., **Aggregation phenomena of collagen**, Chapter 2 in *Biophysical Properties of the Skin*, H. R. Elden, Ed., pp. 63-100 (John Wiley & Sons, Inc., New York, N.Y., 1971).

Key words: aggregation; collagen; fibrils; hydrophobic bonding; native-type fibril formation; phase transition; precipitation kinetics.

Various aggregation phenomena exhibited by dissolved collagen are reviewed. Main consideration is given to native-type fibril formation. The kinetics and thermodynamics of this precipitation process are examined. Subtopics included are phase diagram determinations, hydrophobic bonding aspects, time-dependent changes in the reversibility of native-type fibril precipitation, and the role of polyanions. The review is concluded with discussion of collagen fibril formation in vivo.

14246. Clough, R. B., Simmons, J. A., **A theory of multiaxial plasticity based on integral dislocation dynamics**, *Acta Met.* **22**, 513-521 (May 1974).

Key words: dislocations; plasticity; thermal activation.

A macroscopic theory of isotropic plastic flow under multiaxial stress states is developed from considerations of thermally activated dislocation motion on discrete randomly-oriented slip planes. The resulting equations are in agreement with classical plasticity theory. Yielding is volume-preserving, pressure-independent, and the principal stress and principal strain axes coincide. The flow surface is constructed on the basis of constant power dissipation of plastic flow, and has a variable shape and orthogonal strain vector. For most materials, the predicted flow surface resembles the Tresca yield surface at low temperatures and approaches the von Mises yield surface as its high temperature limit. Other applications are discussed.

14247. Cook, R. K., **Foreword and introduction for the Symposium on Atmospheric Acoustics and Noise Propagation**, *J. Acoust. Soc. Am.* **55**, No. 5, 926 (May 1974).

Key words: acoustics; aircraft noise; atmospheric acoustics; infrasound; noise propagation; sound propagation.

Foreword and introduction for the Symposium on Atmospheric Acoustics and Noise Propagation.

14248. Copley, J. R. D., Rowe, J. M., **Density fluctuations in liquid rubidium. I. Neutron-scattering measurements**, *Phys. Rev. A* **9**, No. 4, 1656-1666 (Apr. 1974).

Key words: coherent scattering function; density fluctuations; liquid rubidium; molecular dynamics; neutron scattering and potential.

We report neutron-scattering measurements of the coherent scattering function  $S(Q, \omega)$  of liquid rubidium at 315 K, in the

range of wave vectors  $1.25 \leq Q \leq 5.5 \text{ \AA}^{-1}$ . In this range there is no evidence of peaks at finite  $\omega$  in  $S(Q, \omega)$  plotted at constant  $Q$ . On the other hand the Fourier transform  $F(Q, t)$  exhibits structure, notably for  $Q = 2.0 \text{ \AA}^{-1}$ , which indicates at least two characteristic (wavelength-dependent) relaxation times in the liquid. For wave vectors  $> 3.0 \text{ \AA}^{-1}$ ,  $F(Q, t)$  may be characterized by a single relaxation time. These results, in conjunction with our results for  $Q < 1.0 \text{ \AA}^{-1}$ , offer the possibility of detailed comparisons with models of the liquid state and with molecular-dynamics calculations.

14249. Cox, J. E., Hein, R. A., Waterstrat, R. M., **Superconducting properties of Al5 phase V-Pt alloys**, *Proc. 12th Int. Conf. on Low Temperature Physics, Kyoto, Japan, Sept. 4-10, 1970*, pp. 333-334 (Mar. 1971).

Key words: Al5 compounds; atomic ordering; critical magnetic field; superconducting; superconductivity; transition temperatures.

Superconducting transition temperatures,  $T_0$ , and initial slopes of the critical magnetic field curves are reported for V-Pt alloys of the Al5 crystal structure. Increased atomic ordering produces an increase in  $T_0$ , contrary to our previous results.

14250. Piermarini, G. J., Braun, A. B., **Crystal and molecular structure of  $\text{CCl}_4$  III: A high pressure polymorph at 10 kbar**, *J. Chem. Phys.* **58**, No. 5, 1974-1982 (Mar. 1973).

Key words: carbon tetrachloride; crystal structure; diamond-anvil cell; high pressure; polymorphism.

The crystal and molecular structure of a high pressure form of carbon tetrachloride ( $\text{CCl}_4$  III) was determined at approximately 10 kbar using a diamond-anvil beryllium pressure cell and a modified Buerger-type precession camera.  $\text{CCl}_4$  III crystallizes in the monoclinic system with a unit cell of the following dimensions:  $a = 9.079 \pm 0.012 \text{ \AA}$ ,  $b = 5.764 \pm 0.003 \text{ \AA}$ ,  $c = 9.201 \pm 0.004 \text{ \AA}$ , and  $\beta = 104.29 \pm 0.05^\circ$ . The space group is  $P2_1/c$  with four molecules per unit cell. Observed infrared spectra indicate that the  $\text{CCl}_4$  molecule exhibits regular tetrahedral symmetry at 10 kbar. By using an approximation to the repulsion energy in a least-squares refinement procedure considering only nonbonded Cl-Cl interactions, an approximate structure was obtained. Subsequent structure factor calculations using a grid-point sampling procedure yielded a final structure with a reliability factor of 9.56 percent.  $\text{CCl}_4$  III is isostructural with  $\text{SnBr}_4$ , and contains closest nonbonded Cl-Cl distances of  $3.49 \text{ \AA}$ , significantly less than the normal Van der Waals separation of  $3.6 \text{ \AA}$ . Taking four molecules per unit cell, the calculated density is  $2.190 \text{ g cm}^{-3}$ . A more compact phase than  $\text{CCl}_4$  III was predicted in the  $\text{CCl}_4$  system on the basis of packing efficiency and the predicted phase ( $\text{CCl}_4$  IV) was subsequently verified by visual observation in microscopic studies at pressures in the 35-40 kbar range and temperatures up to  $500^\circ\text{C}$ .

14251. Righini, F., Cezairliyan, A., **Pulse method of thermal diffusivity measurements (a review)**, *High Temp.-High Pressures* **5**, 481-501 (1973).

Key words: heat transfer; thermal conductivity; thermal diffusivity; thermophysical properties; transient techniques; transport properties.

The pulse (flash) method of measuring thermal diffusivity is reviewed. The basic theory of such measurements is presented and theoretical advances to account for departures from simplified assumptions are discussed. The experimental systems for thermal diffusivity measurements employing the pulse method are described and a summary of investigations reported in the literature is given. Emphasis is placed on the analysis of the accuracy of the method. Potentials of the technique for improved measurements at high temperatures are discussed.



**14252.** Achenbach, P. R., **Energy conservation in buildings: Its foundation, cost, and acceptance**, *Proc. Conf. Energy Conservation: Implications for Building Design and Operation*, Bloomington, Minn., May 23, 1973, pp. 44-73 (1973).

Key words: building design; building performance; building research; building systems; energy conservation; energy use; mechanical systems.

Changes in building practice could save substantial amounts of energy and ease the impending shortages of fuel in the United States. However, changes that are technically sound must also be economically sound, and they must be implemented on a broad scale by the building industry if they are to have a significant impact on fuel usage. The National Bureau of Standards is carrying out significant analytical, laboratory and field investigations of promising technology in energy-saving potential of these building practices. The more extensive field studies are collaborative efforts with other Federal agencies. Concurrently, existing technical information on energy conservation is being collected and prepared as brochures for convenient use by the building design profession and for use in building standards and specifications of various Federal agencies. The program of the National Bureau of Standards on energy conservation in building is summarized and research opportunities in the field are identified for both new and existing buildings.

**14253.** Tsai, D. H., MacDonald, R. A., **Heat pulse propagation in a crystal: A molecular dynamical calculation**, *Solid State Commun.* **14**, No. 11, 1269-1273 (1974).

Key words: anharmonicity; crystal; heat pulse; lattice; molecular dynamics; second sound; stress wave; temperature wave; thermal relaxation.

The propagation of a heat pulse into a perfect bcc crystal is studied by means of molecular dynamical calculations. We observe second sound waves associated with the heat pulse as well as with longitudinal and transverse elastic pulses. Our results explain a number of features observed in second sound experiments and suggest that second sound is a phenomenon of general occurrence.

**14254.** Treu, S., **Techniques and tools for improving the interactive system interface**, (Proc. Interactive Bibliographic Systems, Gaithersburg, Md., Oct. 4-5, 1971), *U.S. Atomic Energy Commission Symp. Series* **28**, pp. 32-38 (Apr. 1973).

Key words: data collection techniques; interactive system interface; retrieval systems; user-system interface.

This is an account of a brief talk presented to the User Interface Session of the Forum on Interactive Bibliographic Systems. Consistent with the planned panel format of that Session, it is not a formally prepared paper. After some assertions about the need for considering the user and his system to be a team and about having to recognize user behavior and satisfaction in assessment of team performance, the use of more unobtrusive techniques for pertinent data collection is advocated. Two tools for enabling these techniques are described: a dialogue monitor which can record the entire two-way message stream and certain related timing data, and a user stimulation system which can actively manipulate the interaction while collecting data on resulting user satisfaction.

**14255.** Taylor, P. O., Dolder, K. T., Kauppila, W. E., Dunn, G. H., **Measurement of spiraling in a magnetically confined electron beam for use in collision studies**, *Rev. Sci. Instrum.* **45**, No. 4, 538-544 (Apr. 1974).

Key words: electron gun; measurement of spiraling; spiraling.

A method is described to directly measure mean spiral diameter in a magnetically confined electron beam. In collision experi-

ments, spiraling affects polarization measurements and effective path length assessment; and in experiments using colliding beams, the collision energy or energy spread can be significantly altered. The technique described here allows experimental correction for these effects. Magnitudes of transverse velocities from various causes leading to spiraling are estimated on the basis of models. A gun designed for use in crossed beam electron-ion excitation experiments is described, and results of tests on spiraling and space charge effects for this gun are given. The tests generally indicate the modeling to be correct. Judicious choice of operating conditions led to path length corrections as small as  $4 \pm 2$  percent at 3 eV, decreasing to  $0.25 \pm 0.2$  percent at 200 eV.

**14256.** Watson, R. E., Bennett, L. H., **Charge transfer in alloys: The blind men and the elephant**, (Proc. Twin Symp. sponsored by the Committee on Alloy Phases of the Inst. of Metals, Univ. of Pennsylvania, Philadelphia, May 1973), Chapter in *Charge Transfer/Electronic Structure of Alloys*, L. H. Bennett and R. H. Willens, Eds., pp. 1-21 (Published by the Metallurgical Society of AIME, Inc., New York, N.Y., 1974).

Key words: alloys; atomic volume; charge transfer; chemical bonding; internal conversion; isomer shift.

This paper attempts to provide an introduction to the concepts underlying much of the discussion in the papers presented at the Symposium on Charge Transfer in Alloys. It also concentrates on two related methods of obtaining charge transfer information in alloys which are not covered elsewhere in the Symposium, namely, the Mössbauer isomer shift and internal conversion experiments.

**14257.** Sugar, J., **Revised ionization energies of the neutral actinides**, *J. Chem. Phys.* **60**, No. 10, 4103 (May 15, 1974).

Key words: actinium; americium; berkelium; californium; curium; einsteinium; fermium; ionization energy; mendelevium; neptunium; nobelium; plutonium; protactinium; thorium; uranium.

Revised values for the ionization energies of the neutral actinide atoms based on new experimental data are given.

**14258.** Ryan, J. V., **Standards for textiles in the U.S.A.**, *Gottlieb Duttweiler Institutes J.* **2**, No. 5, 35-41 (May 1971); *Polymer News* **1**, Nos. 6-7, 10-18 (1973).

Key words: beds; carpets; Child Protection Act; fabrics; flammability; Flammable Fabrics Act; Hill-Burton Act.

Mandatory standards for flame-resistant textiles, or related materials, are authorized under the Flammable Fabrics Act (Department of Commerce), the Child Protection Act amendments to the Federal Hazardous Substances Act (Department of Health, Education, and Welfare), the Hill-Burton and Medicare Acts (Department of Health, Education, and Welfare), the National Highway Safety Act (Department of Transportation), and the basic Acts of the U.S. Coast Guard and the Federal Aviation Administration. Of these Statutes, the Flammable Fabrics Act is the most comprehensive, including within its scope all wearing apparel and interior furnishings for homes, offices, and places of assembly or accommodation. Standards are authorized also under State and local laws, particularly those relating to building or fire codes. Flammability requirements in purchase specifications have the force of law when made part of a contract.

Standards or proposed standards have been published for wearing apparel, carpets and rugs, small carpets and rugs, toys, floor coverings in hospitals and long term care facilities, merchant ships, aircraft cabin liners and furnishings, and motor vehicles. Building and fire codes usually set requirements only for textile furnishings in places of assembly. Purchase specifications rarely include flammability requirements except when the intended use is regulated by statutory requirements.



14260. Evans, A. G., **Fracture mechanics determinations**, (Proc. Conf. on Fracture Mechanics of Ceramics, Pennsylvania State Univ., University Park, Pa., July 11-13, 1973), Chapter in *Fracture Mechanics of Ceramics*, R. C. Bradt, D. P. H. Hasselman, and F. F. Lange, Eds., 1, 17-48 (Plenum Publ. Corp., New York, N.Y., 1974).

Key words: ceramics; failure prediction; fracture mechanics; materials development; techniques.

Techniques for the evaluation of fracture mechanics parameters are described. The selection of techniques for various ceramic applications is discussed, emphasizing the particular problems encountered with these measurements in ceramic systems. Finally, the application of fracture mechanics parameters to problems in both materials development and failure prediction in ceramic systems is described.

14261. Dick, C. E., Lucas, A. C., Motz, J. W., Placious, R. C., Sparrow, J. H., **Large-angle  $K$  x-ray production by electrons**, *J. Appl. Phys.* **44**, No. 2, 815-826 (Feb. 1973).

Key words: aluminum; beryllium; carbon; copper; electron excitation; gold;  $K$  x-ray beams; purities; silver; titanium; yields.

Experimental values are given for the yields and spectral energy purities of  $K$  x-ray beams emitted at 120 and 180° from various targets when bombarded by 0.01- to 3.0-MeV electron beams. Yields and purities are determined for beryllium, carbon, aluminum, titanium, copper, silver, and gold targets as a function of the target thickness and target inclination angle.

14262. Andrews, J. R., **Random sampling oscilloscope for the observation of mercury switch closure transition times**, *IEEE Trans. Instrum. Meas.* **IM-22**, No. 4, 375-381 (Dec. 1973).

Key words: mercury switch; oscilloscope; picosecond; pulse; random sampling; risetime; sampling; transition time.

With the advent of new miniaturized mercury (Hg) switches with reputed transition times of the order of 10 ps, interest has been rekindled in their use in high-speed pulse measurements. Since there is no pretrigger signal available from a Hg switch, normal sequential sampling techniques are not useable to measure the fast Hg switch transition time. For this reason, a new random sampling time base unit was designed to perform these measurements at the low repetition rate of Hg switches. The time base may be used with commercial sampling oscilloscope systems through suitable interconnection terminals or possible interface equipment. It features three selectable time windows of 1  $\mu$ s, 100 ns, and 10 ns. Using its time magnifier, the fastest sweep rate is 10 ps/cm. A variable trigger lead time control is provided. The trigger sensitivity is 5 mV.

14263. Dickens, B., Brown, W. E., Kruger, G. J., Stewart, J. M.,  **$\text{Ca}_4(\text{PO}_4)_2\text{O}$ , tetracalcium diphosphate monoxide. Crystal structure and relationships to  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$  and  $\text{K}_3\text{Na}(\text{SO}_4)_2$** , *Acta Crystallog.* **B29**, Part 10, 2046-2056 (Oct. 1973).

Key words: crystal structure; hydroxyapatite; single crystal x-ray diffraction; structural relationships; tetracalcium phosphate; twinning.

$\text{Ca}_4(\text{PO}_4)_2\text{O}$ , tetracalcium diphosphate monoxide, crystallizes in the monoclinic unit cell  $a=7.023$  (1),  $b=11.986$  (4),  $c=9.473$  (2) Å,  $\beta=90.90$  (1)° (at 25 °C) in space group  $P2_1$  with 4 $[\text{Ca}_4(\text{PO}_4)_2\text{O}]$  per cell. 3288 x-ray data were measured from a single crystal by  $\theta$ -2 $\theta$  scans using Mo  $K\alpha$  radiation; 56 of these reflections were of "unobservable" intensity. The structure was solved by an application of direct phasing methods and subsequent calculation of an  $E$  map. It was refined anisotropically by full-matrix least squares to  $R_w(F)=0.036$ ,  $R(F)=0.037$ . Al-

lowance was made for isotropic secondary extinction but not for anomalous scattering or absorption. The dimensions of the unit cells of  $\text{Ca}_4(\text{PO}_4)_2\text{O}$  and  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$  (hydroxyapatite), an idealized form of the major inorganic phase in the human body, are simply related. Although this 3-dimensional relationship in the unit-cell shapes is not carried over into the details of the actual structures,  $\text{Ca}_4(\text{PO}_4)_2\text{O}$  does contain a layer which is similar to a layer in  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$ , and an epitaxial relationship between the two compounds is conceivable.  $\text{Ca}_4(\text{PO}_4)_2\text{O}$  is also related to the  $\text{K}_3\text{Na}(\text{SO}_4)_2$  (glaserite) structure. In this relationship the oxide ions are "extra" ions. One Ca ion in  $\text{Ca}_4(\text{PO}_4)_2\text{O}$  is weakly coordinated to a face of a  $\text{PO}_4$  group, a feature which has been previously observed for Ca only in a disordered cation site in  $\beta$ - $\text{Ca}_3(\text{PO}_4)_2$ . The two crystallographically discrete oxide ions are surrounded by tetrahedra of Ca ions, with  $\text{Ca}\cdots\text{O}$  distances in the range 2.136 (4) to 2.277 (3) Å. Thus, the oxide ions do not lie in a channel formed by cations in the structure and  $\text{Ca}_4(\text{PO}_4)_2\text{O}$  cannot be considered to be an oxyapatite. The positions of the P atoms and the Ca and oxide ions lie close to those required by space group  $Pm\bar{c}n$ . This explains the appreciable twinning exhibited by  $\text{Ca}_4(\text{PO}_4)_2\text{O}$ . It also makes the existence of a higher-symmetry modification feasible.

14264. DeVoe, J. R., Shideler, R. W., Ruegg, F. C., Aronson, J. P., Shoenfeld, P. S., **Computer utility for the analytical laboratory**, *Anal. Chem.* **46**, No. 4, 509-520 (Apr. 1974).

Key words: computer control; laboratory automation; teleprocessor.

The use of a parallel digital data bus as part of an elaborate teleprocessor system enables the analytical chemist to utilize computer control of his instrument in a manner which is simpler than has been previously described. The use of pushbuttons and thumbwheels with data display, plot, or print in the laboratory, coupled with interactive control of the experiment control program, provides a capability in computer control of instrumentation that approaches the concept of a computer utility. The teleprocessor and software used in a multiprogram environment are described.

14265. Barnes, J. A., Winkler, G. M. R., **The standards of time and frequency in the U.S.A.**, *Proc. 26th Annual Frequency Control Symp., Atlantic City, N. J., June 6-8, 1972*, pp. 269-278 (Electronic Industries Assn., Washington, D.C., 1972).

Key words: astronomical time; atomic time; frequency; International Atomic Time; management; NBS; standard time; time; USNO.

The National Bureau of Standards (NBS) and the U.S. Naval Observatory (USNO) are the two organizations chiefly involved in distributing accurate and precise time and frequency information within the U.S.A. The NBS is responsible for the "custody, maintenance, and development of the national standards" of frequency and time (interval) as well as their dissemination to the general public. The mission of the USNO includes the "provision of accurate time" as an integral part of its work concerned with the publication of ephemerides in support of navigation and in the establishment of a fundamental reference system in space.

Both agencies provide the U.S. contribution to the Bureau International de l'Heure (BIH) [International Time Bureau], which has the responsibility of publishing definitive values of Universal Time (UT), International Atomic Time (LAT), and Coordinated Universal Time (UTC).

14266. Davies, J. B., **A least-squares boundary residual method for the numerical solution of scattering problems**, *IEEE Trans. Microwave Theory Tech.* **MTT-21**, No. 2, 99-104 (Feb. 1973).

Key words: electromagnetic scattering; least-squares; numerical solution; point-matching.



An explicit least-squares criterion is put forward as an alternative to the point-matching method of numerically solving scattering problems. While being an established method of functional approximation, it has been largely ignored in numerical approaches to electromagnetic scattering.

In contrast to point matching, the least-squares approach has a rigorous proof of convergence. An electric/magnetic weighting factor is found useful in optimizing convergence. Finally, it allows use of perhaps the fastest and most compact matrix inversion algorithm.

- 14267.** Deslattes, R. D., Sauder, W. C., **Intercomparison of micrometer, nanometer and picometer wavelengths**, (Proc. 4th Int. Conf. on Atomic Masses and Fundamental Constants, Teddington, England, Sept. 6-10, 1971), Chapter in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds. 4, 337-347 (Plenum Press, London, England, 1972).

Key words: Avogadro's number; Compton wavelength; gamma-ray wavelength; lattice parameters; x-ray conversion factor; x-ray wavelengths.

Reckoning of a common baseline by x-ray and optical interferometry impinges on several fundamental measurements. Our program involves successive wavelength-lattice parameter-lattice parameter-wavelength transfers. Aside from unification of the visible and x-ray and  $\gamma$ -ray wavelength scales, we aim at Avogadro's constant and the electron's Compton wavelength. This report outlines the program, gives current progress, and mentions residual problems.

Requirements for high resolution linear and angular measuring engines have been met by extensions of available technology. Similarly, density measurements as refined from classical buoyant weighings by Bowman and Schoonover appear adequate.

- 14268.** Bay, Z., **The constancy of the velocity of light and prospects for a unified standardization of time, frequency and length**, (Proc. 4th Int. Conf. on Atomic Masses and Fundamental Constants, Teddington, England, Sept. 6-10, 1971), Chapter in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds. 4, 323-336 (Plenum Press, London, England, 1972).

Key words: accuracy limits in interferometry; experimental evidences for constancy of speed of light; unified primary standard for time and length.

Light propagation in vacuum is experimentally proven to be dispersionless to within accuracies exceeding by many orders those of measurements in metrology. The independence of  $c$  relative to the motion of the frame connected to the moving earth is established less accurately, but accurate enough for metrology; any departure from constancy would affect length measurements, based on wavelength standards, or based on  $c$ , in the same way. It can be expected that in the not too distant future 1) optical frequencies in the infrared and visible spectrum can be measured at least as accurately as length can be measured, and 2) that the speed of light will be known to the accuracy of the present length standard. If 1) and 2) materialize then, on both theoretical and practical grounds, the unified standardization of time interval, frequency and length via an agreed upon value of  $c$  will be preferable to a system based on a frequency standard and on a wavelength standard.

- 14269.** Allan, D. W., Blair, B. E., Davis, D. D., Machlan, H. E., **Precision and accuracy of remote synchronization via portable clocks, Loran C, and network television broadcasts**, *Proc. 25th Annual Symp. on Frequency Control, Atlantic City, N.J., Apr. 26-28, 1971*, pp. 195-208 (Electronic Industries Assn., Washington, D.C., 1971).

Key words: cesium beam standards; frequency standards; Loran C; portable clocks; time synchronization; TV timing.

Three precise timing centers in the U.S. have made remote time comparisons for over a year using three different synchronization methods. The timing centers were the U.S. Naval Observatory (USNO), Washington, D.C.; Newark Air Force Station (NAFS), Newark, Ohio; and the National Bureau of Standards (NBS), Boulder, Colo. The synchronization methods were cesium beam portable clocks; Loran C transmissions from North Carolina and Indiana; and ABC, CBS, and NBC live network TV broadcasts common to the three timing centers. Cesium beam portable clocks, having capabilities of accurately and precisely synchronizing remote clocks to within  $0.1 \mu\text{s}$ , formed the basis of comparison. This method is one of the most accurate now available. The Loran C data were taken over a 3150 km (1958 mi) ground wave path, which is believed the longest such path studied with the precision and accuracy of our results. The long term precision between the three remote time centers was better than  $2 \mu\text{s}$  via Loran C; the accuracy of these data is limited by  $10 \mu\text{s}$  ambiguity in identifying the proper cycle of the 100 kHz pulse train. The precision of the TV broadcasts in synchronizing remote clocks was 30 ns  $T^{12} d^{-12}$ , where  $T$  is in days. Factors such as occasional rerouting of TV network signals limited the accuracy. Relative frequency stabilities between ensembles of cesium beam standards at the three time centers were a few parts in  $10^{14}$  for sample times of about three months.

- 14270.** Fath, J. M., **The sound of America today**, *Proc. 26th National Home Appliance Conference on Today's Realities*, Boston, Mass., Nov. 29-Dec. 1, 1972, pp. 115-117 (Association of Home Appliance Manufacturers, Chicago, Ill., 1972).

Key words: home noise; noise sources; recreational; work.

An audio/visual presentation of various noise sources encountered in our daily lives at home, at work, and in recreational activities. The presentation was followed with a discussion of the general problems associated with noise in America today.

- 14271.** Madey, T. E., Yates, J. T., Jr., Erickson, N. E., **X-ray photoelectron spectroscopic study of the adsorption of  $\text{N}_2$  and NO on tungsten**, *Surface Sci.* 43, 526-544 (1974).

Key words: chemical shifts; chemisorption; ESCA; nitric oxide; nitrogen; spectroscopy; x-ray photoelectron.

X-ray photoelectron spectroscopy (ESCA) has been used in a study of  $\text{N}_2$  and NO adsorbed on a polycrystalline tungsten ribbon. The sample was flash cleaned under ultrahigh vacuum conditions, and cooled to either 300 or 100 K for the adsorption studies. Large chemical shifts, as great as 8 eV, were observed between the N(ls) spectra associated with the weakly chemisorbed  $\gamma$ -nitrogen states and the strongly chemisorbed  $\beta$ -nitrogen states. Chemical shifts in both the N(ls) and O(ls) spectra suggest that NO is largely nondissociatively chemisorbed at 100 K. In general, the binding energies of N(ls) and O(ls) electrons in the adsorbed layers are *smaller* than the binding energies for the same atoms in small gaseous molecules. In addition, the binding energies associated with the weakly-bound states of NO and  $\text{N}_2$  are invariably greater than the binding energies associated with strongly chemisorbed species.

- 14272.** Page, C. H., **Definitions of electromagnetic field quantities**, *Amer. J. Phys.* 42, 490-496 (June 1974).

Key words: definitions; electromagnetism; fields.

A logically consistent set of definitions of the electromagnetic field quantities is extremely difficult to find in the literature. Most textbooks either evade the problem, or present definitions that are applicable only to special cases. A philosophy of this problem is presented, and a consistent system developed.



**14273.** Allan, D. W., Barnes, J. A., **Some statistical properties of LF and VLF propagation**, (Proc. AGARD/EPC 13th Symp., Ankara, Turkey, Oct. 9-12, 1967), Chapter 15 in *AGARD Conference Proceedings No. 33, Phase and Frequency Instabilities in Electromagnetic Wave Propagation*, K. Davies, Ed., pp. 219-230 (Technivision Services, Slough, England, July 1970).

Key words: flicker noise; phase fluctuations of VLF and LF transmissions; statistical analysis.

A statistical analysis has been conducted on the day-time phase fluctuations of the standard frequency and time Radio Stations WWVB (60 kHz) and WWVL (20 kHz) as received at Palo Alto, Calif., and of WWVB as received at the National Research Council, Ottawa, Canada. The analysis technique allows a meaningful determination of the low frequency spectral density, of the variance of the phase and frequency fluctuations, and of some cross-correlations. The analysis techniques used are appropriate for commonly encountered nonstationary as well as stationary noise processes.

The results of the analysis yielded a spectral density of the time fluctuations proportional to the reciprocal spectral frequency ( $S_f(\omega) = h/|\omega|$ , flicker noise) for the propagation noise on both WWVL and WWVB. The value of  $h$  was equal to  $7.9 \times 10^{-14} \text{ s}^2$  for WWVL and  $2.2 \times 10^{-14} \text{ s}^2$  for WWVB for the Palo Alto path, and  $h$  was  $4.4 \times 10^{-14} \text{ s}^2$  for WWVB over the Ottawa path. For flicker noise phase modulation a good model of the standard deviation of the fractional frequency fluctuations is:  $\sigma = k|\tau|^{-1}$ , where  $\tau$  is the sample time in days. The values of  $k$  were  $2.4 \times 10^{-11} \text{ days}$  for WWVL and  $1.2 \times 10^{-11} \text{ days}$  for WWVB over the Palo Alto path and  $1.8 \times 10^{-11} \text{ days}$  for WWVB over the Ottawa path.

A cross-correlation coefficient of  $-0.6$  was found between WWVL and WWVB for the Palo Alto path. A linear combination of the two transmissions improved the flicker noise level by a factor of 11.5 over WWVL and by a factor of 2.7 over WWVB, allowing a precision of frequency measurement of  $1 \times 10^{-12}$  for a nine day average any time of the year and of  $1 \times 10^{-12}$  for a five day average over the summer months.

**14274.** Pyke, T. N., Jr., Blanc, R. P., **Networking challenges: The user's viewpoint**, (Proc. EDUCOM Fall Conf., Princeton, N.J., Oct. 9-11, 1973), Chapter 14 *Transportability of Instructional Systems in Facts and Future*, pp. 211-217 (EDUCOM, The Intercommunication Council, Princeton, N.J., 1974).

Key words: computer network; network access machine; network measurement machine; network user; resource sharing; user services.

A number of problems that impede the effective sharing of computer and information resources are identified and discussed. Taking examples from the use of present research and operational resource sharing networks, the difficulties associated with measuring and comparing performance of services provided, identifying and comparing costs to the end user, and determining the amount of effort required on the part of the user to successfully utilize a computer network are presented. Some approaches toward the solution of these problems are also discussed.

**14275.** Field, R. W., English, A. D., Tanaka, T., Harris, D. O., Jennings, D. A., **Microwave optical double resonance spectroscopy with a cw dye laser: BaO  $X^1\Sigma$  and  $A^1\Sigma$** , *J. Chem. Phys.* **59**, No. 5, 2191-2203 (Sept. 1, 1973).

Key words: cw dye laser; double resonance; microwave; spectroscopy.

A tunable, single frequency, continuous wave, dye laser has been used to optically pump various lines of the BaO  $A^1\Sigma - X^1\Sigma$  electronic transition. Microwave optical double resonance

(MODR) spectra are recorded as changes in the intensity of dye laser induced photoluminescence. Fourteen microwave rotational transitions in the  $X^1\Sigma$  ( $v=0,1$ ) and  $A^1\Sigma$  ( $v=0-5$ ) states of  $^{138}\text{Ba}^{16}\text{O}$  and one transition in the  $A^1\Sigma$  ( $v=1$ ) state of  $^{137}\text{Ba}^{16}\text{O}$  have been observed. Partially deperturbed rotational constants obtained for BaO  $A^1\Sigma$  are  $B(v) = 0.25832(2) - 0.001070(5)(v + 1/2) \text{ cm}^{-1}$ . Two physical models are described which account for microwave optical double resonance effects in the strong (non-linear) and weak (linear) optical pumping limits. Observed changes in photoluminescence polarization caused by excited state microwave transitions are predicted by a semiclassical transition dipole model. A three level steady state kinetic treatment of microwave optical double resonance indicates that the BaO MODR transitions reported in this paper are observed near the strong optical pumping limit. It is shown that for most allowed transitions in diatomic molecules a 100 mW single frequency, dye laser is sufficiently intense to significantly deplete rotational levels of the electronic ground state with respect to neighboring rotational levels and to cause the populations of the depleted ground state and optically pumped excited state levels to become comparable.

**14276.** Velapoldi, R. A., Reisfeld, R., Boehm, L., **Quantum efficiencies and transition probabilities of  $\text{Eu}^{3+}$  in silicate glasses**, *Phys. Chem. Glasses* **14**, No. 6, 101-106 (Dec. 1973).

Key words: europium; fluorescence; lifetimes; luminescence; nonradiative rates; oscillator strengths; quantum efficiencies; radiative rates; rare earths; silicate glasses.

Absorption, excitation, and emission spectra of Eu(III) in silicate glasses have been measured. The oscillator strengths for transitions from the populated  $^7F$  multiplet have been calculated and compared with those in other matrices. Quantum efficiencies were determined by comparative and lifetime measurements. Percentage quantum efficiencies for the  $^5D_1 \rightarrow ^5D_0$  transitions and radiative and nonradiative rate constants were calculated.

**14277.** Weinstein, B. A., Piermarini, G. J., **First and second order Raman scattering in GaP to 128 kbar**, *Physics Lett.* **48A**, No. 1, 14-16 (May 20, 1974).

Key words: diamond-anvil cell; gallium phosphide; Raman scattering.

One- and two-phonon room temperature Raman spectra of GaP were measured to 128 kbar using a diamond-anvil pressure cell. Linear and quadratic pressure coefficients were determined for phonons at  $\Gamma, L, (X \rightarrow K)$ , and  $\Sigma$ . The results suggest possible "soft" mode behavior for TA(L) and TA( $X \rightarrow K$ ) phonons.

**14278.** Evans, A. G., Wiederhorn, S. M., **Crack propagation and failure prediction in silicon nitride at elevated temperatures**, *J. Mater. Sci.* **9**, 270-278 (1974).

Key words: elevated temperatures; failure prediction; silicon nitride; slow crack growth.

A technique for studying high temperature crack propagation in ceramic materials is developed. The technique is used to obtain relationships between the crack propagation rate and the stress intensity factor for hot-pressed silicon nitride up to 1400 °C. The data are then used to develop proof test diagrams which give values for the safe working stress levels for this material after proof testing (or any other flaw detection procedure).

**14279.** Franklin, A. D., Crissman, J., Young, K. F., **Point defect interactions in  $\text{CaF}_2:\text{GdF}_3$** , *J. Phys. C* **9**, C9-179-C9-183 (Nov.-Dec. 1973).

Key words: anelastic relaxation;  $\text{CaF}_2$ ; dielectric relaxation; EPR lifetime broadening;  $\text{GdF}_3$ ; pairs; point defects.

The reorientation of the point-defect pair formed in  $\text{CaF}_2$  crystals by substitutional  $\text{Gd}^{3+}$  and interstitial  $\text{F}^-$  ions has been



studied using EPR lifetime broadening measurements and dielectric and anelastic relaxation studies at temperatures between liquid N<sub>2</sub> and room. The GdF<sub>3</sub> concentration ranged from 0.01 to 0.3 mole percent. The crystals were annealed in an atmosphere of He and HF at temperatures from 600 to 800 °C and quickly cooled. Three major relaxations were observed in the anelastic temperatures corresponding well to two major relaxations observed in the dielectric spectrum. The most important of these correlated both in relaxation parameters and intensity changes upon annealing and/or changing concentration of GdF<sub>3</sub> with the lifetime broadening and intensity of the EPR spectrum from the nearest-neighbor pair. The entire pattern has the proper symmetry for the pair with relaxation modes generated by excursions of the F<sup>-</sup> interstitial out to third-neighbor positions, assuming that the most stable positions are closest to the Gd<sup>+3</sup> ions. However, this model is inconsistent with the relative intensities of the dielectric relaxations, and it is concluded that at least two distinct centers must be present.

**14280.** Mandel, J., **The evaluation of standard test methods**, *Stand. News* **2**, No. 4, 17-20 (Apr. 1974).

Key words: interlaboratory studies; measurement; precision accuracy; test methods.

Test methods can be classified into two types: those for which the quantity to be measured is defined independently of the test method and those for which it is defined in terms of the test method. In either case, the evaluation of the precision and accuracy of single measurements can be made only in terms of the characteristics of the method itself. The study of a test method requires the postulation of a mathematical model which in turn determines the proper statistical method of data analysis. The interpretation of the results must be made in terms of the requirements imposed on the method by its practical applications.

**14281.** Krell, J. M., Sams, R. L., **Vibration-rotation bands of nitrous oxide: 4.1 micron region**, *J. Mol. Spectrosc.* **51**, No. 3, 492-507 (June 1974).

Key words: Coriolis interaction; Fermi resonance; high resolution; H<sub>2</sub>O; infrared; perturbation allowed transitions.

The infrared spectrum of nitrous oxide has been measured and analyzed from 2265 cm<sup>-1</sup> to 2615 cm<sup>-1</sup>. Newly refined effective rotational constants for twenty-one vibrational states of <sup>14</sup>N<sub>2</sub>O, three vibrational states each of <sup>14</sup>N<sub>2</sub><sup>18</sup>O and <sup>15</sup>N<sup>14</sup>N<sup>16</sup>O, two states of <sup>14</sup>N<sup>15</sup>N<sup>16</sup>O and one state of <sup>14</sup>N<sub>2</sub><sup>17</sup>O have been calculated.

The most interesting features observed are two ΔΣ "forbidden" bands, 04<sup>2</sup>0-00<sup>0</sup>0 and 12<sup>2</sup>0-00<sup>0</sup>0. These bands occur because of Coriolis interaction between unperturbed vibrational states having *l* = 0 and *l* = 2.

**14282.** Durig, J. R., Carreira, L. A., Lafferty, W. J., **Spectra and structure of small ring compounds. Microwave spectrum of cyanocyclobutane**, *J. Mol. Spectrosc.* **46**, No. 2, 187-193 (May 1973).

Key words: cyanocyclobutane; dipole moment; microwave spectrum; molecular structure; ring conformation; rotational constants.

The rotational spectrum of cyanocyclobutane has been investigated in the region 18.0-40.0 GHz. Only A-type transitions were observed. R-branch assignments have been made for the ground state and the first three excited states of the ring puckering mode as well as the first two excited states of the out-of-plane cyano-bending mode. The microwave data are consistent with a bent equilibrium ground state for the ring with the cyano-group in the equatorial position. The dipole moment components were determined to be  $\mu_a = 4.04 \pm 0.09$  D and  $\mu_c = 0.92 \pm 0.03$  D with the total dipole moment,  $\mu$ , having a value of  $4.14 \pm 0.09$  D.

**14283.** Ambrose, J. R., Kruger, J., **Tribo-ellipsometry: A new technique to study the relationship repassivation kinetics to stress corrosion**, *Corrosion* **28**, No. 1, 30-35 (Jan. 1972).

Key words: repassivation kinetics; steel; stress corrosion; tribo-ellipsometry.

Since the susceptibility of a material to stress corrosion cracking (SCC) may be related to the rupture of a protective film and the repassivation rate of the material thus exposed, a technique, tribo-ellipsometry, has been developed which simulates film rupture by abrading off the surface oxide. During the subsequent repassivation of the exposed surface, this technique allows simultaneous determination of film growth kinetics by ellipsometry and current transients during that time interval following removal of the oxide film. The major advantage of the technique is that the ellipsometric transient allows one to determine which part of the current transient is responsible for repassivation and which part is involved in metal dissolution. The utility of the technique is demonstrated by comparing repassivation rates for a low carbon steel in a sodium nitrate solution in which the metal is susceptible to SCC to those in a sodium nitrite solution, in which it is not. Results obtained using this method indicate that the repassivation rate is slower at elevated temperatures in the nitrate than it is in the nitrite, and that a larger proportion of the current is involved in metal dissolution in the nitrate. This may offer an insight into the reasons for observed susceptibility of mild steels to SCC in such nitrate environments.

**14284.** Wiederhorn, S. M., Evans, A. G., Roberts, D. E., **A fracture mechanics study of the Skylab windows**, Chapter in *Fracture Mechanics of Ceramics*, R. C. Bradt, D. P. H. Haselman, and F. F. Lange, Eds., **2**, 829-841 (Plenum Publ. Corp., New York, N.Y., 1974).

Key words: crack growth; fracture mechanics; glass; static fatigue; structural design; windows.

Design criteria based on fracture mechanics concepts are developed for spacecraft windows. Critical stress intensity factor data and crack velocity data are used for lifetime predictions and for the development of acceptance tests for the eight candidate glass compositions for the Skylab. Design charts are presented which give the minimum time to failure of the Skylab windows as a function of service stress and proof test stress. Surface adsorbed water is shown to be detrimental to the strength of spacecraft windows, even after the spacecraft has left the earth's atmosphere, because of the slow rate of evaporation of water from surface cracks.

**14285.** Wilson, W., Swartzendruber, L. J., **A flexible least squares routine for general Mössbauer effect spectra fitting**, *Computer Phys. Commun.* **7**, 151-162 (1974).

Key words: FORTRAN; least squares fitting; Mössbauer effect; numerical analysis.

A FORTRAN version of a versatile and flexible least squares fitting routine for Mössbauer effect data is described.

**14286.** Fromhold, A. T., Jr., Coriell, S. R., Kruger, J., **Transport and thermodynamic analyses of steady-state currents in solids**, *J. Phys. Soc. Japan* **34**, No. 6, 1452-1459 (June 1973).

Key words: electrochemistry; Gibbs-Duhem; local equilibrium; nonequilibrium thermodynamics; oxidation of metals; solid state diffusion; transport in solids.

The usual derivation of the well-known Gibbs-Duhem relation (or its electrochemical analog) from equilibrium thermodynamics is based on certain assumptions which are only approximately met for nonhomogeneous systems; the postulate of local equilibrium generally employed in nonequilibrium thermodynamics is commonly utilized to extend the results to the nonequilibrium domain. The application of the electrochemical



Gibbs-Duhem relation to the particular case of several charged diffusing species in a solid is utilized herein to obtain an expression for the local electric field which is then compared with an expression for the field deduced by an ordinary phenomenological transport analysis. The two approaches yield consistent results only in the limit of thermodynamic equilibrium. Implications of the analyses are pointed out for the special problem of the growth of oxides and similar tarnish films on metals.

**14287.** Bennett, L. H., Cuthill, J. R., McAlister, A. J., Erickson, N. E., Watson, R. E., **Electronic structure and catalytic behavior of tungsten carbide**, *Science* **184**, 563-565 (May 1974).

Key words: catalysis; density of states; magnetic exchange enhancement; Pt; W; WC.

Tungsten carbide has been shown to be an effective catalyst for a number of reactions that are readily catalyzed by platinum, but not at all by tungsten, and it was speculated that this behavior is due to changes in the electron distribution when carbon is added to tungsten. A test of this hypothesis, made by measuring the valence band x-ray photoelectron spectrum of tungsten carbide and comparing it with the spectra of tungsten and platinum, shows that, near the Fermi level, the electronic density of states of tungsten carbide more nearly resembles that of platinum than that of tungsten.

**14288.** Tetelman, A. S., Evans, A. G., **Failure prediction in brittle materials using fracture mechanics and acoustic emission**, Chapter in *Fracture Mechanics of Ceramics*, R. C. Bradt, D. P. H. Hasselman, and F. F. Lange, Eds. 2, 895-924 (Plenum Publ. Corp., New York, N.Y., 1974).

Key words: acoustic emission; failure prediction; fast crack propagation; fracture mechanics; slow crack growth.

Acoustic emission testing has found many uses in recent years and new applications are constantly being uncovered. The interesting areas for application lie in failure prediction and the characterization of the microscopic processes of yielding and fracture, and the macroscopic processes of slow crack growth and onset of fast crack propagation. This paper has described these applications and emphasized that the total counts and count rate depend on the energy released per event and the density of events per unit of deformation. Where models are presented, they should be regarded as first order approximations which await confirmation.

**14289.** McNesby, J. R., **Standard reference materials for air pollution**, *Proc. Tech. Conf. on the Observation and Measurement of Atmospheric Pollution (TECOMAP)*, Helsinki, Finland, July 30-Aug. 4, 1973, Special Environmental Report No. 3, 595-603 (World Meteorological Organization, Geneva, Switzerland, 1974).

Key words: air pollution; Standard Reference Materials.

The compatibility and accuracy of air pollution measurements depends strongly upon the integrity of the measurement standards to which calibration gases are referred. For this reason it is essential that great care be exercised in establishing scientifically their integrity. The emphasis at the U.S. National Bureau of Standards is being placed upon the development of Standard Reference Materials for those air contaminants designated by the U.S. Environmental Protection Agency as ambient air pollutants, i.e., particulate matter, SO<sub>2</sub>, NO<sub>x</sub>, CO, hydrocarbons, and photochemical oxidants. Standard Reference Materials must be developed also in different concentration ranges for automobile exhaust and for point source effluents. All of these categories are under development at the National Bureau of Standards.

**14290.** Wiederhorn, S. M., **Subcritical crack growth in ceramics**, Chapter in *Fracture Mechanics of Ceramics*, R. C. Bradt, D.

P. H. Hasselman, and F. F. Lange, Eds. 2, 613-646 (Plenum Publ. Corp., New York, N.Y., 1974).

Key words: ceramics; crack growth; delayed failure; fracture; proof testing.

Subcritical crack growth that causes delayed failure is discussed in terms of fracture mechanics concepts. Techniques of characterizing subcritical crack growth are presented and the available crack growth data are discussed with particular emphasis on fracture mechanisms. Finally a design technique is presented to predict useful component lifetime from crack growth data after proof testing.

**14291.** Clark, J. E., **A proposed flammability standard for children's sleepwear**, *Proc. 4th Annual Meeting of the Information Council on Fabric Flammability*, New York, N.Y., Dec. 3, 1970, pp. 142-149 (1970).

Key words: accidents; children; clothing; fabrics; flammability; sleepwear; standards.

Developments toward a flammability standard for children's sleepwear are presented. The basis is reviewed for the legal finding that a standard is needed. The laboratory research studies and the analysis of accident investigation reports are summarized.

The proposed standard provides a vertical test method which uses char length and afterflame time criteria to determine the flammability of children's sleepwear. The procedure, apparatus and care label requirements are outlined.

**14292.** McLaughlin, W. L., Kosanić, M., **The gamma-ray response of pararosanine cyanide dosimeter solutions**, *Int. J. Appl. Radiat. Isotop.* **25**, No. 6, 249-262 (June 1974).

Key words: dosimetry; dyes; dye yield; gamma rays; pararosanine cyanide; 4,4',4"-triaminotriphenylacetone; triphenyl-methane dyes.

Triphenylmethane dye derivatives, especially the colorless nitriles in organic or aqueous solution, serve as convenient radiation dosimeters. With large absorbed doses (10<sup>3</sup>-10<sup>6</sup> rads), permanent ionized dye is produced with sufficient color for routine photometric measurement. If a polar solvent is used and the solution is oxygenated and stabilized by weak acid, the optical density measured at the absorption maximum of dye is a linear function of dose. Dye yield varies with the type of solvent, concentration of the dye precursor, temperature during irradiation, acid and oxygen content and batch of dye precursor used. Additions of small amounts of acid to solutions prevent back reactions. Dissolved oxygen or a weak oxidizing agent helps extend the dose range of response by scavenging free-radical agents formed in the solvent during irradiation. Suitable plastic containers may be used, without the need for ultraclean handling procedures or superdistilled solvents. Since the main sources of systematic error are easily controlled and since the new dosimeter solutions may be used over a wide dose range, they show advantages over other chemical dosimeters for many applications.

**14293.** Clark, J. E., Tovey, H., **Priorities for fabric flammability investigations**, *Proc. 5th Annual Meeting of the Information Council on Fabric Flammability*, New York, N.Y., Dec. 9, 1971, pp. 208-214 (1972).

Key words: accident data; apparel standard (CS 191-53); fire safety; Flammable Fabrics Act; ignition sources; mandatory standards.

A broad attack is necessary in order to reduce deaths, injuries, and property loss from fabric fires. Standards on the flammability of fabrics are greatly needed and careful study is necessary to ensure that these standards are, as the law requires, reasonable, appropriate, and technologically practicable.



In addition, improvements in standards and engineering design of common heat sources could well contribute to significant reduction of clothing ignitions.

Further study of use and packaging of flammable fluids can be expected to lead to reduced hazard. But much more knowledge is needed in this area before optimum recommendations can be made.

Improved and uniform building fire codes could also contribute to improved occupant safety, through wider use of smoke and fire detectors, audio-visual warning systems, self-closing doors, and automatic sprinklers.

Finally, we must continue and greatly increase our education efforts so that the consumer has an increased awareness of the fabric fire problem, and concomitant knowledge of proper fire prevention and extinguishment procedures.

**14294.** Currie, L. A., Filliben, J. J., DeVoe, J. R., **Statistical and mathematical methods in analytical chemistry**, *Anal. Chem. Ann. Rev.* **44**, 497R-512R (Apr. 1972).

Key words: chemical analysis; curve fitting; distribution functions; experiment planning and optimization; measurement process; on-line computers; recognition techniques; review; statistics; transforms.

The statistical and chemical literature are surveyed for the period October 1967 to October 1971, with emphasis on work related to the application of mathematical statistics to analytical chemistry. Principal categories covered include: Reviews, Conferences, Journal and Books; Method Characterization; Planning and Optimization of Experiments; Curve Fitting; On-line Computers; and Other Topics (techniques for testing basic statistical assumptions; special distributions; transforms, correlation and signal/noise enhancement; recognition techniques). The bibliography, consisting of somewhat less than 600 references, contains mostly English-language journals and books, but important foreign-language articles—particularly French, German and Russian—also appear.

**14295.** DeVoe, J. R., **A laboratory based multi-instrument computer system**, (Proc. Int. Conf. on Modern Trends in Activation Analysis, Saclay France, Oct. 2-6, 1972), *J. Radioanal. Chem.* **15**, 657-667 (1973).

Key words: computer; digital communication system; laboratory automation; multi-program monitor.

Design of computer system for assistance in the operation of experiments contains certain factors unique to a particular laboratory. Details are given on the procedure that was used to generate design criteria and to implement such a design for a computer system in the Analytical Chemistry Division, NBS. The system is currently servicing ten instruments (ranging from spectrophotometers to mass spectrometers) with a projected capacity exceeding sixty depending upon the type of instruments connected.

**14296.** DeVoe, J. R., **Automation and computerization of analytical measurements**, *Proc. Seminar Series on Chemistry and Biology of Trace Metals in the Environment, University of Illinois, Urbana, Ill., Spring 1971*, pp. 147-162 (University of Illinois Press, Urbana, Ill., 1972).

Key words: computer; digital communication system; laboratory automation; multi-program monitor.

Design of computer systems for assistance in the operation of experiments contains certain factors unique to a particular laboratory. Details are given on the procedure used to generate design criteria and to implement such a design for a computer system in the Analytical Chemistry Division, National Bureau of Standards.

**14297.** Garfinkel, S. B., Mann, W. B., Schima, F. J., Unterweger, M. P., **Present status in the field of internal gas counting**, (Proc. First Int. Summer School on Radionuclide Metrology, Herceg Novi, Yugoslavia, Aug. 21-Sept. 1, 1972), *Nucl. Instrum. Methods* **112**, No. 1/2, 59-67 (Sept.-Oct. 1973).

Key words: argon-37; carbon-14; internal gas counting; radioactive standardization; tritium; xenon-131m.

The gas-counting equipment at the National Bureau of Standards has been recently modified and reconstructed. The preparation of various radioactivity gaseous standards will be described. In some cases purity is assured by a prior separation in the isotope separator.

**14298.** Selig, H., Sarig, S., Abramowitz, S., **Alkali fluorotellurates (VI)**, *Inorg. Chem.* **13**, 1508-1511 (1974).

Key words: alkali hexafluorotellurates; inorganic complex; intermediate phases; structure; thermodynamic analysis.

The reactions of tellurium hexafluoride with cesium fluoride or rubidium fluoride go nearly to completion if the alkali fluorides are suspended in the inert solvent,  $C_6F_6$ . With cesium fluoride a limiting composition of  $CsF \cdot TeF_6$  is approached, while rubidium fluoride gives compounds of composition  $2RbF \cdot TeF_6$ . Thermogravimetric analyses of the products show various inflection points indicating the existence of intermediate products stable at higher temperatures. Complete decomposition of the complexes is not achieved up to the melting points of the alkali fluorides, except in some cases under prolonged pumping. The infrared and Raman spectra of the materials have been tentatively interpreted in terms of  $D_{sh}$  and  $D_{4d}$  structures for the  $TeF_7^-$  and  $TeF_8^{2-}$  anions, respectively.

**14299.** Hutchinson, J. M. R., Mann, W. B., Mullen, P. A., **Sum-peak counting with two crystals**, (Proc. First Int. Summer School on Radionuclide Metrology, Herceg Novi, Yugoslavia, Aug. 21-Sept. 1, 1972), *Nucl. Instrum. Methods* **112**, No. 1/2, 187-196 (Sept.-Oct. 1973).

Key words: aluminum-26; bismuth-207; cobalt-60; niobium-94; radioactivity standardization; sodium-22; sum coincidence counting; yttrium-88.

Very great improvements in accuracy of measurements of radioactivity by the sum-peak technique of coincidence counting have been achieved by the utilization of two NaI(Tl) crystals.

Taking advantage of the coincidence and anticoincidence possibilities in this arrangement, equations and techniques have been developed, so that accuracies obtainable by the sum-peak technique are improved by an order of magnitude, and become comparable to those obtainable by means of conventional  $\beta$ - $\gamma$  and  $\gamma$ - $\gamma$  coincidence counting.

Good statistical accuracy can be obtained quickly, and many small but often laboriously determined corrections which appear in  $\beta$ - $\gamma$  and  $\gamma$ - $\gamma$  coincidence counting, are important in this new method, which has been applied to the standardization of  $^{60}Co$ ,  $^{94}Nb$ ,  $^{88}Y$ ,  $^{22}Na$ ,  $^{26}Al$  and  $^{207}Bi$ .

**14300.** Hutchinson, J. M. R., Mann, W. B., Perkins, R. W., **Low-level radioactivity measurements**, (Proc. First Int. Summer School on Radionuclide Metrology, Herceg Novi, Yugoslavia, Aug. 21-Sept. 1, 1972), *Nucl. Instrum. Methods* **112**, No. 1/2, 305-318 (Sept.-Oct. 1973).

Key words: aluminum; anticoincidence shielding; bovine liver assay; copper; low-level radioactivity; radioactivity intercomparisons; steel.

Low-level radioactivity measurements are reviewed. Alpha- and  $\beta$ -particle, and  $\gamma$ -ray low-level-radioactivity counting is discussed, and various detector systems are compared for detection sensitivity. Low-level measurements on bovine liver stan-



standard reference material, and radioactive contamination in industrial samples of aluminum, copper, and steel are reviewed. The results of low-level radioactivity intercomparisons are discussed.

- 14301.** Garfinkel, S. B., Mann, W. B., Pararas, J. L., **The National Bureau of Standard  $4\pi$   $\beta$ - $\gamma$  coincidence-counting and  $\gamma$ -ray intercomparator automatic sample changers**, (Proc. First Int. Summer School on Radionuclide Metrology, Herceg Novi, Yugoslavia, Aug. 21-Sept. 1, 1972), *Nucl. Instrum. Methods* **112**, No. 1/2, 213-217 (Sept.-Oct. 1973).

Key words: radioactivity measurements;  $4\pi$   $\beta$ - $\gamma$  coincidence counting;  $\gamma$ -ray intercomparator automatic sample changers.

Instruments of very simple and somewhat novel design will be described. The  $4\pi$   $\beta$ - $\gamma$  changer holds from 1 to 30 carriers of sources, each of which can be counted for any preset number, up to 10, of counting periods. The  $\gamma$ -ray changer accommodates from 1 to 24 source carriers. In comparing  $\gamma$ -ray source count rates, the detector-to-source distances for individual sources are carefully controlled.

- 14302.** Mann, W. B., **Radioactive calorimetry—a review of the work at The National Bureau of Standards**, (Proc. First Int. Summer School on Radionuclide Metrology, Herceg Novi, Yugoslavia, Aug. 21-Sept. 1, 1972), *Nucl. Instrum. Methods* **112**, No. 1/2, 273-277 (Sept.-Oct. 1973).

Key words: intercomparative measurements; nickel-63; radioactive calorimetry; radioactive standardization.

Calorimetric measurements in the field of radioactivity will be reviewed with special reference to the standardization of  $^{63}\text{Ni}$ . Intercomparative measurements with the National Research Council of Canada and Atomic Energy of Canada Limited will be discussed.

- 14303.** Cavallo, L. M., Coursey, B. M., Garfinkel, S. B., Hutchinson, J. M. R., Mann, W. B., **Needs for radioactivity standards and measurements in different fields**, (Proc. First Int. Summer School on Radionuclide Metrology, Herceg Novi, Yugoslavia, Aug. 21-Sept. 1, 1972), *Nucl. Instrum. Methods* **112**, No. 1/2, 5-18 (Sept.-Oct. 1973).

Key words: intercomparisons; radioactivity; standards; traceability.

With the enormous and world-wide increase in the applications of radioactive materials in so many scientific and technological fields, a corresponding need has arisen for increased skill and improved facilities for the assay of such materials. In the U.S.A., the use of radioisotopes, including radiopharmaceuticals is about \$80 million annually. The measurements skills and facilities must of necessity tend to lag behind such a rapid growth, and increasingly from many quarters we at the National Bureau of Standards are being requested for help in establishing a consistent measurements system in radioactivity traceable both to us and through us to the international measurements system. This paper will discuss the measures that we are taking in order to achieve such traceability in a consistent measurements system in different fields of radioactivity, with special emphasis on environmental and radiopharmaceutical measurements.

- 14304.** Lawless, W. N., **Dielectric cooling technology: 15–4.2 K**, (Proc. Cryogenic Cooler Conf., USAF Academy, Colo., Oct. 16-17, 1973), Chapter in *Closed Cycle Cryogenic Cooler Technology and Applications* **1**, 417-440 (AF Flight Dynamics Lab., (FEC), Wright-Patterson AFB, Ohio, Dec. 1973).

Key words: adiabatic polarization; cooling technology; dielectric cooling; glass-ceramics; magnetic thermal valve; mechanical thermal valve; refrigeration, solid-state;  $\text{SrTiO}_3$ .

A comprehensive analysis of a proposed dielectric refrigerator operating in a closed cycle between a load at 4.2 K and a reservoir at 15 K is presented. The working dielectric material is a  $\text{SrTiO}_3$  glass-ceramic, for which the dielectric equation of state is experimentally determined. Hysteretic phenomena, breakdown strength, and phonon-polarization data are presented and discussed. A realistic engineering model for the refrigerator is described and analyzed, including parasitic thermal loads and losses. Some of the dimensional parameters of the model maximize the performance, and these optimal dimensions are physically reasonable. Computer analyses are made of these models, which are right circular cylinders of diameter D and height D. The results are that the net powers absorbed from the load at 4.2 K vary from 1 to 50 W for D-values between 5 and 20 cm and for cycle times  $\sim$  second. These results are shown to be relatively insensitive to the choice of metals used for the electrodes and heat conductors in the model (Rh, Pt, W, Cr, Cu) or to the approximations employed. A joint development program between the National Bureau of Standards and Corning Glass Works is underway to develop a prototype dielectric refrigerator along the lines discussed in this paper.

- 14305.** Voth, R. O., Petropoulos, S. K., **Cryogenic refrigerators for shipboard forward looking infrared applications**, (Proc. Cryogenic Cooler Conf., USAF Academy, Colo., Oct. 16-17, 1973), Chapter in *Closed Cycle Cryogenic Cooler Technology and Applications* **1**, 27-33 (AF Flight Dynamics Lab., (FEC), Wright-Patterson AFB, Ohio, Dec. 1973).

Key words: cryogenics; infrared detector; low capacity; reliability; shipboard; 77 K refrigerator.

The Naval Ordnance Laboratory (NOL) has asked the Cryogenics Division of the National Bureau of Standards to investigate and evaluate 1) commercially available refrigerators, 2) refrigerators under development, and 3) new or novel ideas applicable to a refrigerator to cool infrared detectors in a shipboard Forward Looking Infrared (FLIR) system. The FLIR requires a refrigerator capacity of approximately 2 watts at 77 K and a physical configuration allowing for an interface to the FLIR unit. Information was collected by interviewing FLIR manufacturers, surveying refrigerator manufacturers and by contacting users of similar systems. Correlation of this information with the NOL requirements is presented herein. The primary difference between airborne/spaceborne refrigerators and a shipborne refrigerator is the accessibility for minor repairs on-board ship although major repairs may be deferred for extended periods of time. It is anticipated that the shipboard units will operate away from major maintenance facilities, for periods as long as 6 months, with the refrigerator operating at least half of this time. Thus, reliability and ease of maintenance are emphasized when evaluating the various systems.

- 14306.** Haller, W., Blackburn, D. H., Simmons, J. H., **Miscibility gaps in alkali-silicate binaries—data and thermodynamic interpretation**, *J. Amer. Ceram. Soc.* **57**, No. 3, 120-126 (1974).

Key words: alkali-silicates; glass; immiscibility; lithium-silicate binary; melts; miscibility gaps; sodium-silicate binary; thermodynamics.

Measurements of the miscibility gaps in the  $\text{Li}_2\text{O}$ - and  $\text{Na}_2\text{O}$ - $\text{SiO}_2$  binaries are reported and compared to data of other workers. Heat treatments by brief immersion in liquid Sn were used for measuring the properties of glasses with a strong devitrification tendency. The miscibility-gap boundaries of both systems are successfully described by modified regular-mixing equations based on the concept that the thermodynamic mixing processes are controlled by complex but discrete molecular structures which exist in the melt. The assumptions and implications of the model are discussed.



**14307.** Collins, R. C., Haller, W., **Protein-sodium dodecyl sulfate complexes: Determination of molecular weight, size and shape by controlled pore glass chromatography**, *Anal. Biochem.* **54**, No. 1, 47-53 (July 1973).

Key words: chromatography; controlled pore glass chromatography; molecular size; porous glass chromatography; protein; protein-sodium dodecyl sulfate complexes; sodium dodecyl sulfate-complexes.

Protein-SDS complexes chromatographed on controlled pore glass elute linearly with log molecular weight over a range from 17,000 to 385,000 daltons. A glass with a pore size of approximately 500 Å allows the inclusion of all complexes in this range.

Exclusion size analysis of the individual complexes gives from 120 to 423 Å as their longest dimension.

**14308.** Cassidy, E. C., Hebner, R. E., Jr., Zahn, M., Sojka, R. J., **Kerr-effect studies of an insulating liquid under varied high-voltage conditions**, *IEEE Trans. Elec. Insul.* **EI-9**, No. 2, 43-56 (June 1974).

Key words: electric fields; electrical measurements; high voltage measurements; insulating liquids; Kerr effect; nitrobenzene; space charge.

Refined Kerr electrooptical fringe-pattern methods are used to study time and space variations in the electric field between the electrodes of parallel-plate capacitors filled with liquid nitrobenzene. Photographs of fringe-pattern data recorded during application of high direct (both positive and negative) and sinusoidal voltages, ranging in frequency from 40 to 200 Hz, are compiled to enable computation of space-charge distortions of the field bulk of the liquid during the stress of high-field (up to 85-kV/cm) operation. The measurements reveal significant differences between the field and charge behavior under short pulse (microsecond) voltage conditions, during prolonged dc operation, after sudden changes in the dc voltage level and polarity, and, for the first time, at various intervals over the course of entire cycles of sinusoidal voltage. The results show that space-charge distortion in the interelectrode field is influenced by the level, frequency, and duration of applied voltage. Discussions of effects believed due to particulate charge carriers, to electrohydrodynamic motion of the liquid, and to the electrode materials are also included.

**14309.** Unassigned.

**14310.** Iverson, W. P., **Tests in soils**, (Proc. Symp. on State-of-the-Art in Corrosion Testing ASTM Annual Meeting, June 21-26, 1970, Toronto, Canada), Chapter 21 in *Handbook on Corrosion Testing and Evaluation*, W. H. Ailor, Ed., pp. 575-597 (John Wiley & Sons, Inc., New York, N.Y., 1971).

Key words: biological activity; chemical tests; electrochemical tests; pH; polarization measurements; redox-potential; soil corrosivity; soil resistivity.

A review and discussion of various methods used in measuring the corrosivity of soils and thin relative significance.

Methods discussed include soil pH, total ductility redox-potential, redox-capacity, resistivity, chemical tests, biological activity, electrochemical tests, and polarization techniques.

**14311.** Mangum, B. W., **Standard Reference Materials 933 and 934; The National Bureau of Standards' precision thermometers for the clinical laboratory**, *Clin. Chem.* **20**, No. 6, 670-672 (1974).

Key words: clinical laboratory; enzymology; health care; standard reference material; SRM 933; SRM 934; thermometers.

Because many facets of clinical laboratory work, such as enzymatic reactions, pH measurements, and blood-gas analysis, are

highly sensitive to temperature, there is a need to measure temperature accurately and closely control it. To help satisfy these needs and to aid in getting a usable temperature scale into the clinical laboratory, the National Bureau of Standards has developed SRM 933 and SRM 934. These precision thermometers are calibrated at 0, 25, 30, and 37 °C. Their value to the clinical laboratory is described.

**14312.** Newbury, D. E., Christ, B. W., Joy, D. C., **Relevance of electron channeling patterns to embrittlement studies**, *Met. Trans.* **5**, 1505-1508 (June 1974).

Key words: cleavage surfaces; electron channeling contrast; embrittled iron; grain surfaces; scanning electron microscopy.

The new technique of scanning electron microscopy utilizing electron channeling contrast has been applied to the study of fracture surfaces of embrittled iron. The degradation of electron channeling patterns with increasing amounts of surface layer (11 mn deep) deformation is an ideal tool for qualitatively measuring plastic flow in small areas (10 μm diameter) of fracture surfaces. Electron channeling patterns were obtained from grain surfaces and cleavage surfaces. It was always possible to obtain channeling patterns from grain surfaces, but there were many regions on cleavage surfaces where electron channeling contrast was completely eliminated. Variations in the amount of plastic flow were evident from point to point on both grain surfaces and cleavage surfaces.

**14313.** Horn, W. A., **Some simple scheduling algorithms**, *Nav. Res. Logistics Q.* **21**, No. 1, 177-185 (Mar. 1974).

Key words: job scheduling; minimizing maximum lateness; minimizing total delay; multimachine scheduling; scheduling; scheduling algorithms; single-machine scheduling.

This paper considers situations in which jobs require only one operation on a single machine, or on one of a set of identical machines. Penalty-free interruption is allowed. Some simple algorithms are given for finding optimum schedules to minimize maximum lateness and total delay, for the single-machine case, and maximum lateness for a restricted multimachine case. A simple flow problem formulation permits minimizing maximum lateness for the more general multimachine case.

**14314.** Herzberg, G., Hugo, T. J., Tilford, S. G., Simmons, J. D., **Rotational analysis of the forbidden  $d^3\Delta_i \leftarrow X^1\Sigma^+$  absorption bands of carbon monoxide**, *Can. J. Phys.* **48**, No. 24, 3004-3015 (1970).

Key words: absorption spectrum; carbon monoxide; electronic spectrum; forbidden transition; rotational analysis; rotational perturbations.

The forbidden  $d^3\Delta_i \leftarrow X^1\Sigma^+$  transition of CO has been observed in absorption at high resolution in the vacuum ultraviolet region. The intensity distribution in the rotational structure of the observed bands in conformity with the assumption that the transition occurs on account of the interaction between the  $d^3\Delta$  state and a  $^1\Pi$  state, presumably the  $A^1\Pi$  state. Thirteen bands of the  $d - X$  system have been analyzed yielding more extensive rotational data for the  $d^3\Delta_i$  state than were previously known. A discussion of the local perturbations in the  $d$  state by the  $A^1\Pi$  and  $a^3\Pi$  states is included.

**14315.** Horn, W. A., **Minimizing average flow time with parallel machines**, *Oper. Res.* **21**, No. 3, 846-847 (May-June 1973).

Key words: assignment problems; job scheduling; scheduling.

It is noted that the assignment and sequencing of one-machine jobs in a multimachine environment can be formulated as a linear-programming assignment problem. Means for reducing the size and computational difficulty of this problem are identified.



**14316.** Dillon, T. A., Stephenson, J. C., **Calculation of vibrational and rotational energy transfer between HF, DF, HCl, and CO<sub>2</sub>**, *J. Chem. Phys.* **58**, No. 5, 2056-2064 (Mar. 1, 1973).

Key words: energy transfer; HF, DF, CO<sub>2</sub>; linewidth; unitary.

A theory of vibrational energy transfer which retains the exponential form of the scattering operator is applied to energy transfer between vibrationally excited HF, DF, HCl, and CO<sub>2</sub>. The calculations contain several new features, including use of curved classical trajectories and vibrational wavefunctions obtained numerically from RKR potential. Cross sections for multiquantum pure rotational changes caused by the dipole-quadrupole interaction are calculated. These multiquantum rotational transitions play an important role in vibrational energy exchange by allowing large vibrational energy defects to be absorbed by the rotational degrees of freedom. Agreement between theory and experiment is excellent. Cross sections calculated for simultaneous transfer of two vibrational quanta from HF or HCl to CO<sub>2</sub> are very small. However, for DF-CO<sub>2</sub> the calculated two-quantum-transfer cross section is only a factor of 2-6 smaller than that for single-quantum transfer.

**14317.** Billingsley, F. P. II, Krauss, M., **Quadrupole moment of CO, N<sub>2</sub>, and NO<sup>+</sup>**, *J. Chem. Phys.* **60**, No. 7, 2767-2772 (Apr. 1, 1974).

Key words: CO; hyperpolarizability; multiconfiguration SCF; N<sub>2</sub>; NO<sup>+</sup>; quadrupole moment.

Quadrupole moments obtained by a variety of experiments exhibit a wide range of values even for molecules such as CO and N<sub>2</sub>. Previous theoretical values were obtained with Hartree-Fock single-configuration wavefunctions. This study reports quadrupole moments obtained with multiconfiguration self-consistent-field wavefunctions chosen by the optimized valence configuration approach of Wahl and Das. The theoretical MC-SCF quadrupole moments are compared with both the experimental and Hartree-Fock values. Vibrationally averaged values of the quadrupole moments were obtained for CO and NO<sup>+</sup>. The results for the  $\nu=0, J=0$  vibrational level are  $-2.23$  and  $0.56 \times 10^{-26}$  esu cm<sup>2</sup>, respectively.

**14318.** Albares, D. J., **Electron and ion momentum transfer from plasma electrical conductivity in a magnetic field**, *Phys. Fluids* **16**, No. 8, 1252-1258 (Aug. 1973).

Key words: Hall effect; helium; magnetic field; momentum transfer; negative glow plasma.

The electrical conductivity of a partially to strongly (Coulomb collision-dominated) ionized dc plasma in a dc magnetic field was investigated at low frequency by two experimental methods, one utilizing the Hall effect and the other a plasma interaction with an induced solenoidal electric field. Electron-ion and electron-atom momentum transfer collision frequencies and ion mobility in the magnetic field (ion slip) were inferred. The helium abnormal negative glow plasma was used at pressures of 0.5 to 2.5 torr, electron densities of  $1$  to  $32 \times 10^{17}$  m<sup>-3</sup> and temperature  $\approx 600$  K; the magnetic field ranged up to 675 G. The data support Shkarofsky's theory of partial ionization. When ion motion becomes dominant, the resulting ion mobility is 75 percent larger than He<sup>+</sup> mobility in helium taken from drift tube measurements. This disagreement suggests that further theoretical work on ion mobility in a plasma is needed.

**14319.** Gevantman, L. H., Garvin, D., **The compilation and evaluation of chemical kinetics data: A descriptive survey of current efforts**, *Int. J. Chem. Kinet.* **V**, 213-230 (1973).

Key words: chemical kinetics; CODATA kinetics task group; compilation; evaluation; kinetics; national programs; rate constant data.

A description of the current range of activities being pursued in the compilation and evaluation of chemical kinetic data is given. The roles of individual scientists, professional groups, and national and international programs are detailed. The special problems attending on kinetic parameters are enumerated and discussed. An appendix is included which gives a comprehensive list of compilations and evaluations extant in the field of chemical kinetics.

**14320.** Evans, B. J., Swartzendruber, L. J., **Supertransferred hyperfine fields and covalency at diamagnetic cations in magnetic insulators**, *Phys. Rev. B* **6**, No. 1, 223-231 (July 1, 1972).

Key words: antimony; ferrites; hyperfine fields; iron; Mössbauer effect; nickel; valency.

The sign and magnitude of the antimony hyperfine fields has been measured in Sb-substituted nickel ferrite using the <sup>121</sup>Sb Mössbauer effect. We obtain a value of  $-311 \pm 4$  kG for this field at 100 K. This result is compared with results obtained for Sn in yttrium iron garnet and, among the possible mechanisms, 3d-5s covalent spin transfer appears to make the predominant contribution to the hyperfine field.

**14321.** Evenson, K. M., Wells, J. S., Petersen, F. R., Danielson, B. L., Day, G. W., **Accurate frequencies of molecular transitions used in laser stabilization: The 3.39- $\mu$ m transition in CH<sub>4</sub> and the 9.33- and 10.18- $\mu$ m transitions in CO<sub>2</sub>**, *Appl. Phys. Lett.* **22**, No. 4, 192-195 (Feb. 15, 1973).

Key words: CO<sub>2</sub> and He-Ne laser frequency; methane; saturated absorption.

The frequencies of three lasers stabilized to molecular absorptions were measured with an infrared-frequency synthesis chain extending upwards from the cesium frequency standard. The measured values are 29.442 483 315(25) THz for the 10.18- $\mu$ m R(30) transition in CO<sub>2</sub>, 32.134 266 891(24) THz for the 9.33- $\mu$ m R(10) transition in CO<sub>2</sub>, and 88.376 181 627(50) THz for the 3.39- $\mu$ m P(7) transition in CH<sub>4</sub>. The frequency of methane, when multiplied by the measured wavelength reported in the following letter, yields 299 792 456.2 (1.1) m/sec for the speed of light.

**14322.** Ehrlich, M., **Influence of irradiation on the production of F centers in LiF (TLD grade)**, *J. Appl. Phys.* **40**, No. 2, 891-892 (Feb. 1969).

Key words: annealing; F centers; <sup>60</sup>Co gamma-ray irradiation; LiF (TLD grade) plaques; readout; thermoluminescence.

Optically polished samples of extruded plaques of LiF (TLD grade) were given <sup>60</sup>Co gamma-ray exposures ranging from about 35 000-450 000 R, at exposure rates between about  $1.5 \times 10^3$  and  $5 \times 10^6$  R/h. Over this range of exposures and exposure rates, the resulting absorption in the F band was found to be independent of exposure rate, and to increase with exposure, even for exposures for which the thermoluminescence exhibited saturation effects. After thermoluminescence readout at about 235 °C, practically all the absorption in the F band created by the <sup>60</sup>Co gamma-ray exposure had disappeared. These results are compatible with the dominant role given F centers in some of the current models for the thermoluminescence process in LiF (TLD grade).

**14323.** Dillon, T. A., Stephenson, J. C., **Energy transfer during "orbiting" collisions**, *J. Chem. Phys.* **60**, No. 11, 4286-4288 (June 1, 1974).

Key words: energy transfer; infrared lasers; molecular collisions; vibrational exchange.

Semiclassical collision theory is used to calculate the temperature dependence of cross sections for exchange of vibrational excitation from HF and DF to CO<sub>2</sub>. For collisions with kinetic



energy less than four-fifths of the intermolecular potential well depth there exists a narrow range of impact parameter for which the scattering angle exceeds  $2\pi$  (i.e., more than one revolution). That part of the trajectory in excess of a single revolution can be accurately represented by a simple model of a circular orbit with a constant angular velocity replacing the instantaneous classical turning point. Calculations are compared to experimental data and illustrate the significance of multiple revolution collisions.

**14324.** Flynn, J. H., **Thermodynamic properties from differential scanning calorimetry by calorimetric methods**, *Thermochemica Acta* **8**, 69-81 (1974).

Key words: DSC; enthalpy; glass transition; heat capacity; thermal analysis; thermodynamic properties.

Simple theory and techniques are explored and developed to utilize the differential scanning calorimeter for the determination of heat capacities, glass transition and enthalpies of transition between two thermodynamic states of substances. Effects due to the transition kinetics and thermal and electronic lags of the instrument are either corrected for or eliminated.

**14325.** Heydemann, P. L. M., Houck, J. C., **Bulk modulus and density of polyethylene to 30 kbar**, *J. Polym. Sci.* **10**, Part A-2, 1631-1637 (1972).

Key words: bulk modulus; density; equation of state; glass transition temperature; polyethylene; pressure dependence.

The results of bulk modulus and density measurements on low-density polyethylene to 30 kbar are presented. From these data the pressure coefficient  $dT_g/dp$  of the glass transition temperature is obtained, and a comparison is made with data calculated from Pastine's theoretical equation of state for polyethylene.

**14326.** Billingsley, F. P. II, Krauss, M., **Multiconfiguration self-consistent-field calculation of the dipole moment function of CO( $X^1\Sigma^+$ )**, *J. Chem. Phys.* **60**, No. 11, 4130-4144 (June 1, 1974).

Key words: CO; dipole moment; dipole moment functions; infrared intensity; multiconfiguration SCF.

The dipole moment function for the  $X^1\Sigma^+$  ground state of CO in the vicinity of the equilibrium internuclear distance has been calculated by the optimized valence configurations (OVC) multiconfiguration self-consistent-field method. The results are compared with existing Hartree-Fock and configuration interaction treatments of this molecule at single points and also the dipole moment function deduced from experimental infrared intensities. At the experimental equilibrium separation, the calculated dipole moment is  $-0.167$  D ( $C-O^+$ ) which is in reasonable agreement with the microwave value of  $-0.112$  D ( $C-O^+$ ). The vibrationally averaged expectation value of the dipole moment based on the computed moment function and accurate vibrational wavefunctions is  $-0.151$  D ( $C-O^+$ ) which is in better agreement with the observed microwave quantity and illustrates that the effect of vibrational averaging is not negligible in systems such as CO that possess small permanent dipole moments. A general prescription for constructing OVC wavefunctions for diatomic molecules is also presented.

**14327.** Holt, H. K., **Theory of gas lasers and its application to an experiment**, *Phys. Rev. A* **2**, No. 1, 233-249 (July 1970).

Key words: collisions; gas laser; line widths; power output; theory; tuning curves.

The semiclassical theory of gas lasers has been reformulated by adding rate terms to the density-matrix component differential equations. The solution to these equations, in the form of a Fourier series, is applicable at high laser intensities. A calculation of the effect of phase-changing collisions is also included

so that the results can be compared to experimental data taken with a He-Ne laser operating at a wavelength of  $1.15\ \mu\text{m}$ .

**14328.** Heinrich, K. F. J., **Gegenwärtiger stand der klassischen theorie der quantitativen elektronenstrahl-mikroanalyse**, *Mikrochim. Acta.*, Suppl. IV, pp. 252-262 (1970).

Key words: corrections; electron probe microanalysis; quantitative analysis; x-ray spectroscopy.

Although the foundations for a procedure of data reduction in quantitative electron probe analysis have not been changed for several years, there has been progress in the choice of expressions, parameters, and constants. A brief account of recommended expressions and procedures is given. Reference is made to the Standard Reference Materials of Au-Ag and Au-Cu alloys issued for electron probe microanalysis. These are especially useful for investigating the application of correction procedures.

**14329.** Gevantman, L. H., **Survey of analytical spectral data sources and related data compilation activities**, *Anal. Chem.* **44**, No. 7, 30A-48A (June 1972).

Key words: analytical spectral data; automated spectral data sources; data centers; standard reference data.

A broad survey is made of analytical spectra data sources. The activities described include some description of the operative data systems, their location and the type of data issued. The report describes sources for infrared spectra, mass spectrometric data, atomic absorption data, x-ray diffraction data, NMR spectral data (chemical shift), ultraviolet spectra and others. New initiatives for automation and easy access and retrieval in some spectral areas are mentioned.

**14330.** Harrison, J. O., Jr., **The role of standards in data processing**, (Proc. 1969 International Data Processing Conference and Business Exposition, Data Processing Management Association, Montreal, Quebec, Canada, June 16-19, 1969), Paper in *Data Processing*, XIV, 451-458 (Data Processing Management Association, Park Ridge, Ill., 1970).

Key words: codes; compatibility; computers; data interchange; information processing; standards.

Federal information processing standards are for use within the data processing installations of the U.S. Government. They are generally, but not always, adopted from approved U.S.A. standards, and they are reflected in U.S. Government ADP procurement specifications. Federal information processing standards are, for the most part, directed to the solution of compatibility problems such as the interchange of data between and among information systems, the interchange of programs among computers of different makes and models, the interchange of devices and components among different product lines and the interchange of computer related ideas among people. The authoritative source of information on Federal information processing standards is the Federal Information Processing Standards Register issued by the National Bureau of Standards and distributed by the U.S. Government Printing Office.

**14331.** Straty, G. C., **Velocity of sound in dense fluid methane**, *Cryogenics* **14**, No. 7, 367-370 (July 1974).

Key words: compressibility; methane; sound velocity; specific heat ratio.

Measurements of the velocity of sound in saturated and compressed fluid methane are reported. Measurements were made on the saturated liquid from 91 K to 186 K and on the compressed fluid along selected isotherms from 100 K to 300 K at pressures to about  $35\ \text{MN m}^{-2}$ . Data were combined with newly available  $PpT$  data to obtain the isentropic compressibility and the ratio of the specific heats. Measurements along the higher temperature isotherm were limited to densities greater than



about 10 mole l<sup>-1</sup> at 300 K increasing to about 14 mole l<sup>-1</sup> at 210 K due to the large low pressure sound attenuation in methane.

- 14332.** Cornell, D., Tsang, W., **Pyrolysis generation of dilute concentration of sulfur dioxide**, *Anal. Chem.* **46**, No. 7, 933-935 (June 1974).

Key words: pollution; pyrolysis; SO<sub>2</sub>; standards.

SO<sub>2</sub> has been produced in dilute concentrations by pyrolysis of trimethylene sulfone. The decomposition is unimolecular and yields equimolar amounts of SO<sub>2</sub> and C<sub>3</sub> hydrocarbons. Advantages of the method for use in calibration of SO<sub>2</sub> monitors in routine field analytical determinations are discussed.

- 14333.** Davis, D. D., Huie, R. E., Herron, J. T., **Direct rate measurements showing negative temperature dependence for reaction of atomic oxygen with *cis*-2-butene and tetramethylethylene**, *J. Chem. Phys.* **59**, No. 2, 628-634 (July 15, 1973).

Key words: atomic oxygen; gas phase kinetics; olefins.

Reported in this paper are the first direct rate measurements showing a negative temperature dependence for the reaction of ground state atomic oxygen with *cis*-2-butene and tetramethylethylene. Wide variations made in the experimental conditions (e.g., total pressure, O atom concentration, and olefin concentration) of these two systems have shown that the measured rate constants were uninfluenced by secondary reactions. The absence of any dependence of the measured rate constants on total pressure at several temperatures indicate that the reactions investigated were bimolecular processes. When expressed in the form of an Arrhenius equation, the observed negative temperature dependence results in an apparent negative activation energy, i.e.,  $k_{cis-2-B} = (9.69 \pm 0.96) \times 10^{-12} \exp(319 \pm 63 \text{ cal mol}^{-1}/RT)$  and  $k_{TME} = (5.58 \pm 1.07) \times 10^{-12} \exp(1570 \pm 120 \text{ cal mol}^{-1}/RT)$ . Units are in cubic centimeters per molecule seconds. If a threshold energy of 0.0 cal mole<sup>-1</sup> is assigned to the reaction of O(<sup>3</sup>P) with TME, the temperature dependence of the pre-exponential term for a rate expression of the form  $k = A(T)\exp(-E_0/RT)$ ,  $E \geq 0$  is calculated to be  $T^{-2}$ . These new results are discussed in terms of both collision and transition state theories.

- 14334.** Unassigned.

- 14335.** Geltman, S., Hidalgo, M. B., **The Coulomb-projected Born approximation. IV. Ionization of hydrogen**, *J. Phys. B: At. Mol. Phys.* **7**, No. 7, 831-839 (1974).

Key words: Born approximation; hydrogen; ionization; triple differential cross section.

The triple differential cross section for the electron impact ionization of hydrogen atoms is calculated in the Coulomb-projected Born approximation, including exchange, and detailed comparison is made with the ordinary Born result. The calculations are done for a variety of energies and angles of the two secondary electrons in coplanar and noncoplanar geometries. Appreciable differences occur in the results predicted by the various approximations.

- 14336.** Davis, D. D., **Frequency standard hides in every color TV set**, *Electronics* **44**, No. 10, 96-98 (May 10, 1971).

Key words: dissemination frequency; frequency synthesizers; linear phase comparators; television color subcarrier; time.

In color television broadcasting, a color "subcarrier" is transmitted at about 3.58 MHz. It is used as a reference signal in the color television receiver to demodulate the chrominance sidebands. The major U.S. networks use rubidium frequency standards to generate the color subcarrier. This paper describes a method for making use of the color subcarrier as a frequency

standard. The output of a 1 MHz local standard synthesized to 3.58 MHz is used as one input to a phase comparator and is adjusted to agree with the received subcarrier signal. Results of actual network measurements are given.

- 14337.** Unassigned.

- 14338.** Cuthill, J. R., **Grating spectrometers and their application in emission spectroscopy**, Chapter 3 in *X-Ray Spectroscopy*, L. V. Azároff, Ed., pp. 133-172 (McGraw-Hill Book Co., New York, N.Y. 1974).

Key words: excitation methods; gratings; grating spectrometers; photon detectors; soft x rays.

This is a textbook-type chapter on the basic principles and characteristics of grazing incidence grating spectrometers and their components for use in obtaining soft x-ray emission spectra. Correction factors involved in relating the observed soft x-ray emission spectra to the valence band electron density of states is discussed briefly.

- 14339.** Evans, W. H., Grimes, J. J., Jobe, T. L., Henderson, H. A., Beck, D., Beckwith, B., Boyd, R. N., Domalski, E. S., **Bibliography and substance-property index (inorganic), 1968-1973**, *Bull. Thermodyn. Thermochem. Section III. Inorganic Substances* **12**, 267-344, 447-549 (1969); **13**, 226-308, 391-483 (1970); **14**, 183-257, 319-382 (1971); **15**, 211-314, 389-485 (1972); **16**, 261-416, 497-639 (1973).

Key words: inorganic compounds; thermodynamic publications.

Bibliography (authors, title, journal, volume, page, year) and Substance-Property Index of material published from 1968 through 1973. This is a continuation of work done over the past several years and published in earlier editions of the Bulletin.

- 14340.** Harrison, J. O., Jr., **Standards (Computer)**, *McGraw-Hill Yearbook of Science and Technology*, pp. 392-396 (McGraw-Hill Book Co., New York, N.Y., 1973).

Key words: American National Standards Institute; ASCII; COBOL; computers; International Standards Organization; standards.

Computer standards are developed at the international level by ISO/TC 97, Computers and Information Processing, at the American national level by American National Standards Committee X3, and at the U.S. Federal Government level by NBS.

Such standards are devoted to many specific purposes, most of them related to the problems of interchanging data and interchanging programs among different computers. The American Standard Code for Information Interchange and the standardization of COBOL are given as examples.

- 14341.** Filliben, J. J., **Techniques for tail length analysis**, (Proc. 18th Conf. on the Design of Experiments in Army Research Development and Testing, Aberdeen Proving Ground, Md., Oct. 25-27, 1972), *ARO Report 73-2*, Part 2, 425-450 (Department of Defense, Washington, D.C., 1973).

Key words: correlation coefficient; data analysis; distribution analysis; estimation; Fortran subroutine; Lambda distribution; medians; normality; order statistics; probability plot correlation coefficients; probability plots; statistics.

This paper concerns itself with the problem of estimating from a set of data the tail length of the underlying distribution. A probability plot technique for such distributional analysis is developed which makes use of order statistic medians. The probability plot correlation coefficient  $r_D$  for a distribution D is introduced which gives a statistical measure of probability plot linearity. The output from a computerized version (written in



machine-independent ANSI Fortran) of the proposed tail length analysis procedure is illustrated. Three examples are discussed.

- 14342.** Sparks, L. L., **ASRDI oxygen technology survey. Volume IV: Low temperature measurement**, *NASA Spec. Publ. 3073*, 153 pages (National Aeronautics and Space Administration, Washington, D.C., 1974).

Key words: calibration; cryogenics; liquid helium; liquid hydrogen; liquid neon; liquid nitrogen; liquid oxygen; reference data; resistance thermometers; thermocouples; thermometry; vapor pressure.

The specific goal of this review is to present up-to-date information on temperature measurement between the triple and critical point of oxygen. Temperature transducers which can be used in this range are treated over their entire range of usefulness. Three broad types of thermometer are considered—resistance thermometers, thermocouples, and filled systems. In particular, platinum, indium, copper, germanium, carbon, and thermistor resistance thermometers are considered; thermocouple standard types E, K, T, and J plus various combinations utilizing Au-Co and Au-Fe alloys are considered; vapor pressure systems utilizing He, H<sub>2</sub>, Ne, N<sub>2</sub>, and O<sub>2</sub> as fill substances are discussed. Methods of low temperature thermometry are presented along with methods of calibration and analytical representation. Reference data are given in terms of Cragoe Z functions for indium and copper resistance thermometers and resistance ratios for carbon. Reference tables are included for each thermocouple type along with the power series coefficients necessary to generate the tabular data. Tabular vapor pressure data and analytical functions for each fill gas are also included. The relationship of the IPTS-68 temperature scale to previously used scales is discussed.

- 14343.** Huie, R. E., Herron, J. T., **Kinetics of the reactions of singlet molecular oxygen (O<sub>2</sub><sup>1</sup>Δ<sub>g</sub>) with organic compounds in the gas phase**, *Int. J. Chem. Kinet.* **V**, 197-211 (1973).

Key words: air pollution; kinetics; organic compounds; rate constant; reactions; singlet oxygen.

The reactions of singlet molecular oxygen (O<sub>2</sub><sup>1</sup>Δ<sub>g</sub>) with a series of organic compounds have been studied in the gas phase at 298 K. The concentration of singlet molecular oxygen was determined by titration with 2,5-dimethylfuran. The titration technique was checked using a photoionization technique. Absolute rate constants were measured on the basis of the loss of organic reactant and, in some cases, of singlet molecular oxygen. It was found that the usual method of producing singlet molecular oxygen in the gas phase can also, under some conditions, allow reactive species other than singlet molecular oxygen to enter the reactor, leading to serious errors in the determination of rate constants. This problem was eliminated by carrying out the rate measurements in the presence of a small amount of nitrogen dioxide a radical scavenger.

- 14344.** Huntoon, R. D., Lichtenstein, S., **The National Bureau of Standards prepares for the 1970's**, *Science* **165**, 867-874 (Aug. 29, 1969).

Key words: Astin-Branscomb transition; Astin legacy; compatibility and reproducibility of measurements; contributions to basic science; design and performance standards; fundamental constants; international standards; metric system study; National Standard Reference Data System; NBS in the coming decade; public health and safety; self-calibration by users; special NBS facilities.

A retirement story on Allen V. Astin covering his 17 year leadership of the National Bureau of Standards. Discusses Astin's role in acquiring the ultramodern Gaithersburg facility and the nomination of Lewis M. Branscomb as the new director.

- 14345.** Johnson, C. R., **Hadamard products of matrices**, *Linear and Multilinear Algebra* **1**, 295-307 (1974).

Key words: closure; diagonal matrix; *D*-stability; field of values; Hadamard product; inclusion theorem; Kronecker product; numerical radius; spectrum stable matrix.

The entry-wise product of arbitrary  $n \times n$  complex matrices is studied. The principal tools used include the Kronecker product, field of values and diagonal multiplications. Inclusion theorems for the field of values and spectrum are developed in the general case and refined in special cases. These are employed to obtain inequalities involving the real parts of the characteristic roots and the numerical radius, and previously known results are found to be special cases of several of the theorems. In addition, the case of positive stable matrices is considered and a new class of nonnegative stable matrices is introduced, studied and related to *D*-stability.

- 14346.** Quintiere, J., **Radioactive characteristics of fire fighter's coat fabrics**, *Fire Technol.* **10**, No. 2, 153-161 (May 1974).

Key words: firefighters; protective clothing; reflectance; spectral radiation; transmittance.

The results of spectral reflectance measurements are reported for a number of typical and proposed fabrics for the outer shell of firemen's turnout coats. The spectral range of measurement was from 0.35 to 22 μm. Spectral transmittance values are also presented for some samples. From these data total reflectance values were calculated for blackbody source distributions over a range of temperature from 300 to 6000 K and for a solar spectral distribution. The implications of these results are considered for thermal protection and comfort of clothing worn by firefighters.

- 14347.** Holt, D. R., Nahman, N. S., **Coaxial-line pulse-response error due to a planar skin-effect approximation**, *IEEE Trans. Instrum. Meas.* **IM-21**, No. 4, 515-519 (Nov. 1972).

Key words: asymptotic expansion; characteristic impedance; coaxial line; complimentary error function; conductor; cylindrical; dielectric; error; generator; lossy; microminiature; model; planar; propagation function; pulse; receiving end; skin effect; step response; time domain; voltage divider.

The time-domain error introduced by the planar skin-effect approximation is examined by comparing the approximate response with the cylindrical skin-effect response. Expressions are developed for the cylindrical skin-effect response and applied to line outer conductor ID sizes ranging from a 0.1-mm microminiature size to 10 mm. For 50-Ω air dielectric lines (including 3.5 and 7 mm) curves are given for the cylindrical skin-effect response transition (rise) time (0 to 50 percent and 10 to 90 percent) versus line length (0.01-100 m). Step responses are given for a 1-m length of 0.1-mm 50-Ω microminiature line with relative dielectric constants of 1, 2, and 3.

- 14348.** Kirchhoff, W. H., Lide, D. R., Jr., Powell, F. X., **The microwave spectrum, force field and dipole moment of CF<sub>2</sub>**, *J. Mol. Spectrosc.* **47**, No. 3, 491-498 (Sept. 1973).

Key words: CF<sub>2</sub>; dipole moment; force field; microwave spectra; structure.

Measurements of the microwave spectrum of CF<sub>2</sub> have been extended to include transitions up to  $J=40$ . Using these extended measurements, a centrifugal distortion analysis has been performed and from the distortion constants, the force field, infrared spectrum, average structure, Coriolis coupling constants, and inertial defect have been calculated. The original assignment of the infrared spectrum has been confirmed. An improved value for the dipole moment,  $0.469 \pm 0.026$  D, has been obtained.



**14349.** Cohen, J., Vezzetti, C. F., Edelman, S., **Polymeric pyroelectric detector**, (Proc. of the Special Meeting on the Physics of Detectors U.S. Naval Training Device Center, Orlando, Fla., Mar. 15, 1972), Paper in *Proceedings of the Special Meeting on the Physics of Detectors*, pp. 113-117 (Infrared Information and Analysis Center, Institute of Science and Technology, Willow Run Laboratories, University of Michigan, Ann Arbor, Mich., Aug. 1972).

Key words: detector; infrared; polymer; polyvinyl fluoride; polyvinylidene fluoride; pyroelectric.

Polymers have a number of advantages over conventional pyroelectric materials such as triglycine sulphate crystals; for example, they are not hygroscopic, retain their polarization for long times, and are simple and inexpensive to fabricate into detectors. We have been experimenting mainly with films of polyvinylidene fluoride, and to a lesser extent, polyvinyl fluoride. These experiments will be described.

**14350.** Kahn, A. H., Candela, G. A., Walatka, V., Jr., Perlstein, J. H., **Magnetic susceptibility of the one-dimensional electron gas; application to BDP(TCNQ)<sub>2</sub>**, *J. Chem. Phys.* **60**, No. 7, 2664-2669 (Apr. 1, 1974).

Key words: magnetic susceptibility; organic conductors; paramagnetism; TCNQ compounds.

The magnetic susceptibility of the noninteracting electron gas has been studied on the basis of free electrons and the tight-binding model, with application to the properties of organic conducting materials. Theoretical curves of susceptibility versus temperature are presented. The gradual transition from low temperature Pauli paramagnetism to the high temperature Curie law region is shown. In the transition region, the one-dimensional systems show a peak in the susceptibility of the order of 110 percent of the low temperature limit. The magnetic susceptibility of the compound BDP(TCNQ)<sub>2</sub> is interpreted in terms of a one-dimensional tight-binding model with an energy bandwidth of 0.07 eV.

**14351.** Weiss, A. W., **Series perturbations in atomic spectra: Superposition-of-configurations calculations on Al I and Al II**, *Phys. Rev. A* **9**, No. 4, 1524-1536 (Apr. 1974).

Key words: atomic spectra; atomic wave functions; oscillator strengths; series perturbations.

Configuration-interaction calculations, using only Hartree-Fock discrete-state configurations, are reported for the two perturbed series,  $3sn^2F$  of Al II and  $3s^2nd^2D$  of Al I. While good results are obtained for term values and oscillator strengths in Al II, this is not the case for Al I, where the calculations predict the  $3s3p^2$  perturber to be expelled into the continuum. To study this case more closely, superposition of configurations (SOC) calculations, which include all correlation effects, were carried out on the five lowest  $^2D$  states of Al I. These results indicate that the perturber actually remains in the discrete spectrum, but loses its identity and is smeared out over the entire series. New Rydberg orbitals are extracted from the SOC wave functions which are quite different from the Hartree-Fock but very similar to those of the Coulomb approximation. Various truncations of the SOC functions are also analyzed and the implications for the correlation problem discussed.

**14352.** Levin, E. M., **System Y<sub>2</sub>O<sub>3</sub>-GeO<sub>2</sub> below 1700 °C**, *J. Amer. Ceram. Soc.* **57**, No. 4, 189-190 (Apr. 1974).

Key words: germania-yttria system; immiscibility; phase equilibrium; yttria-germania system.

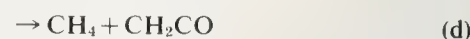
The phase diagram for the system has been determined up to 1700 °C using the quenching technique. Phases were identified with the aid of the polarizing microscope and by x-ray powder diffraction. The system contains three compounds, Y<sub>4</sub>GeO<sub>8</sub>,

Y<sub>2</sub>GeO<sub>5</sub>, and Y<sub>2</sub>Ge<sub>2</sub>O<sub>7</sub>. A region of liquid immiscibility extends from 83.5 to 96.5 mol. percent GeO<sub>2</sub> at 1593 ± 5 °.

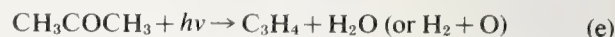
**14353.** Ju-Te Lin, L., Ausloos, P., **Gas phase photolysis of acetone in the far ultraviolet**, *J. Photochem.* **1**, 453-462 (1972/73).

Key words: acetone; far ultraviolet; photolysis; primary processes; quantum yields.

The photolysis of acetone (pressure: 2 to 25 torr, *T*:300 K) was investigated at 147 nm (8.4 eV), 123.6 nm (10 eV) and 106.7 – 104.8 nm (11.6 – 11.8 eV). The quantum yields of the products H<sub>2</sub>, CO, CH<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>2</sub>, C<sub>3</sub>H<sub>8</sub>, C<sub>3</sub>H<sub>6</sub>, C<sub>3</sub>H<sub>4</sub>, and CH<sub>3</sub>COC<sub>2</sub>H<sub>5</sub> were measured both in the presence and absence of free radical scavengers (C<sub>2</sub>H<sub>4</sub> or NO). These data, in conjunction with the results of deuterium-labelling experiments, demonstrated the occurrence of the following primary processes:



It is also suggested that the primary process:



occurs with a quantum yield of ~ 0.02. The quantum yield of "molecular" methane (process d) is 0.02 (147 nm), 0.028 (123.6 nm) and 0.043 (104.8 – 106.7 nm). The quantum of "molecular" hydrogen is 0.03 (147 nm) 0.26 (123.6 nm) and 0.28 (104.8 – 106.7 nm). The quantum yield of process (a) is 0.7 ± 0.1 at 147 nm. At shorter wavelengths the quantum yield of the latter process could not be estimated because of the uncertain fate of the cations [ $\Phi(\text{CH}_3\text{COCH}_3^+) = 0.25$  at 123.6 nm and 0.21 at 104.8 – 106.7 nm] and the extensive dissociation of the internally excited species formed in the primary processes.

**14354.** Heinrich, K. F. J., **Review 3d National Conference on Electron Microprobe Analysis and the 1st Annual Meeting of the Electron Probe Analysis Society of America**, *Applied Optics* **8**, No. 4, 862-863 (1969).

Key words: conference review; electron probe; microanalysis; microscopy; spectroscopy; x rays.

This paper is a review of the Conference mentioned in the title. The review has been requested by the Editorial Consultant of the journal *Applied Optics*, published by the Optical Society of America.

**14355.** Johnson, D. R., Powell, F. X., **Microwave spectrum and structure of sulfur difluoride**, *Science* **164**, 950-951 (May 23, 1969).

Key words: microwave spectroscopy; rotational spectrum; sulfur difluoride; molecular structure; dipole moment; electrical discharge.

Sulfur difluoride has been identified and characterized from its microwave spectrum. The analysis of rotational transitions for both sulfur difluoride-32 and sulfur difluoride-34 shows that this molecular species has C<sub>2v</sub> symmetry with a bond length of 1.589 angstroms, a bond angle of 98°16', and a dipole moment of 1.05 Debye.

**14356.** Johnson, W. T. K., Dick, C. E., **Half-life measurement of several short-lived nuclear isomers**, *Nucl. Instrum. Methods* **99**, 221-226 (1972).

Key words: bromine; cadmium; erbium; gold; half lives; iridium; measurement; nuclear isomers; solenium; tungsten.

Bremsstrahlung produced by 3.5 MeV electrons incident on a platinum target was used to populate nuclear isomers in several



nuclei through excitation of higher lying states. A shuttle was constructed to transport targets of natural isotopic abundance from an irradiation position to a measuring position. Other than a low background the activity measured was due entirely to the isomeric decay. The measured half-lives in seconds are  $^{77m}\text{Se}$ :  $17.58 \pm 0.12$ ,  $^{79m}\text{Br}$ :  $4.97 \pm 0.10$ ,  $^{167m}\text{Er}$ :  $2.28 \pm 0.03$ ,  $^{179m}\text{Hf}$ :  $18.77 \pm 0.07$ ,  $^{183m}\text{W}$ :  $5.56 \pm 0.25$ ,  $^{191m}\text{Ir}$ :  $4.88 \pm 0.03$ , and  $^{197m}\text{Au}$ :  $7.86 \pm 0.04$ . The data are presented and the methods of analysis are discussed. The results are compared to recent literature values.

- 14357.** Hougen, J. T., Bunker, P. R., Johns, J. W. C., **The vibration-rotation problem in triatomic molecules allowing for a large-amplitude bending vibration**, *J. Mol. Spectrosc.* **34**, No. 1, 136-172 (Apr. 1970).

Key words: bending vibration; large amplitude; quasi-linear; theory; triatomic; vibration-rotation.

In this paper we derive an expression for the vibration-rotation Hamiltonian of a triatomic molecule. In the derivation we use a curvilinear bending coordinate and two rectilinear stretching coordinates in such a way that the Hamiltonian obtained is applicable for any triatomic molecule, linear or bent, and allows for large displacements of the bending coordinate (sometimes said to result from the molecule being "quasi-linear" but, in fact, of general occurrence). We derive a zeroth-order Hamiltonian to describe the energy levels associated with the bending vibration, and are able to fit the experimental results on HCN and DCN better than if we had used the standard formalism of rectilinear (and small) displacements. We also use the formalism to describe the dependence of the rotational constant  $B$  on the bending vibrational quantum number and apply the results to the microwave data on CsOH and CsOD.

- 14358.** Sengers, J. M. H. L., **Compressibility, gas**, *Encycl. Phys.* **2d Edition**, pp. 149-151 (1974).

Key words: adiabatic compressibility; density fluctuations; equation of state; isothermal compressibility; speed of sound.

This is an entry for the Encyclopedia of Physics. Isothermal and adiabatic compressibilities are defined. Their experimental behavior is discussed and an explanation of this behavior in terms of molecular theory is given. The most important experimental technique for obtaining these compressibilities are discussed. Some of the newer developments using the theory of the radial distribution functions are indicated. References to general material for further study are given.

- 14359.** Koonce, C. S., **Peierls transitions in semimetallic one dimensional charge transfer salts**, *Solid State Commun.* **14**, No. 11, 1141-1144 (1974).

Key words: charge transfer salts; electronic energy band structure; electron-phonon coupling; one dimension; Peierls transition; tetrathiofulvalinium-tetracyanoquinodimethan (TTF-TCHNQ).

Peierls transitions in one dimensional charge transfer salts in which both donor and acceptor molecules have even valency such as TTF-TCNQ have been studied. Transitions involving macroscopic occupation of phonon states of wavevector  $k_F(\text{TTF}) + k_F(\text{TCNQ}) = 1/2 G$  and  $|k_F(\text{TTF}) - k_F(\text{TCNQ})|$  can occur as well as transitions of wavevector  $2k_F(\text{TTF})$  [and  $2k_F(\text{TCNQ})$ ].

- 14360.** Hoover, T. B., **The frequency extrapolation of conductance data for aqueous salt solutions**, *J. Phys. Chem.* **74**, No. 13, 2667-2673 (1970).

Key words: conductance; conductivity; extrapolation; faradaic process; frequency extrapolation; palladium black;

platinum; polarization; polarization electrode; Standard Sea Water.

Polarization phenomena in conductivity measurements were investigated in order to reduce systematic error in the standardization of solutions intended for the calibration of conductivity cells and salinometers. Data for demal potassium chloride solutions and for Standard Sea Water were obtained with two cells having constants of 37 and 86, respectively, both with bright platinum and with palladium black-coated electrodes. Four empirical and three theoretical functions of resistance vs. frequency were fitted to the data. Correctness of the extrapolation was judged by the agreement of the limiting resistance obtained with bright electrodes with that obtained with coated electrodes. All of the empirical formulas predicted limiting values for the bright electrodes that were lower by 0.02 to 0.15 percent. Equations based on the model of Grahame for the faradaic process, as well as a simplified model, agreed within 0.01 percent while a third theoretical equation was intermediate in accuracy.

- 14361.** Isler, M. A., Stenbakken, G., **Magnetic switches for burglar alarm systems**, *NILECJ-STD-0301.00*, 20 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., Mar. 1974).

Key words: burglar alarm sensor; burglar alarm system; door switch; magnetically actuated; perimeter sensor; switch.

This standard establishes performance criteria for magnetically-actuated switches intended for use in protective intrusion alarm circuits to monitor the position of doors, windows, etc., and to cause the initiation of a signal sufficient to cause auxiliary equipment to send an alarm to a police panel, central station, or a local audible alarm device. Included are requirements and methods of test for materials, performance, and electrical properties. The performance characteristics selected are those that affect the false alarm susceptibility of the device. This standard does not provide performance criteria for resisting attempts to defeat the device through physical or surreptitious attack. This standard is one of a series establishing standards for intrusion alarm sensors, installation, and operation.

- 14362.** Kase, K. R., Domen, S. R., **Calorimetric and ionization measurements of stopping power in carbon for 19.5 GeV electrons**, *Nucl. Instrum. Methods* **118**, 469-475 (1974).

Key words: absorbed dose; calorimeter; carbon; electrons; stopping power.

A portable carbon calorimeter built at the National Bureau of Standards was used in a 19.5 GeV electron beam at the Stanford Linear Accelerator to measure absorbed dose. The dose measurements were normalized to a given number of incident electrons by monitoring the electron intensity with a transmission ion chamber previously calibrated against a quantameter in the same beam. The simultaneous measurements of integrated electron intensity and absorbed dose allowed a direct determination of stopping power in carbon for 19.5 GeV electrons. The measured value of  $1.80 \text{ MeV cm}^2/\text{g}$  is within 6 percent of the calculated value.

- 14363.** Klein, R., **Preparation of contiguous chemisorbed adlayers by sequential deposition and surface migration**, *Surface Sci.* **29**, 309-316 (1972).

Key words: chemisorption; deposition; gas separation; physisorption.

The separation of two sequentially deposited gases on a half shadowed field emission tip by surface migration of the physisorbed layer furnishes a convenient method for the production of distinct, contiguous layers. Oxygen and carbon monoxide on



tungsten as well as ruthenium, and oxygen and nitrogen on ruthenium have been separated in this manner.

- 14364.** Lauritzen, J. I., Jr., Hoffman, J. D., **Extension of theory of growth of chain-folded polymer crystals to large undercoolings**, *J. Appl. Phys.* **44**, No. 10, 4340-4352 (Oct. 1973).

Key words: chain folds; growth rate; isotactic; lamellar thickness; nucleation theory; polyethylene; polymer crystallization; polystyrene; undercooling.

The kinetic theory of the rate of growth  $G$  and the initial lamellar thickness  $l_g^*$  of chain-folded crystals is extended so that it is applicable at high undercoolings. Attention is centered on the details of how the first step element and the first fold are put down on the substrate. A parameter  $\phi$  that varies between zero and unity, which apportions the free energy of attachment of the step element between the forward and backward reactions, is used to denote variations in this process. Expressions for  $G$  are derived from flux equations for two limiting cases: regime I, single surface nucleation act with rapid substrate completion and regime II, numerous surface nucleation acts with very slow substrate completion. Data from the literature on  $G$  for isotactic polystyrene (regime II) and polyethylene single crystals (regime I) are analyzed to obtain surface free energies, and these are used with the revised theory for  $l_g^*$  to predict the lamellar thickness of these polymers. Good agreement between  $l_g^*$  and published data is found for  $1 > \phi > 0$ . Values of  $\phi$  below unity imply that the molecules are physically adsorbed onto the substrate prior to actual crystallographic attachment. A discussion is given of the segmental transport effects that dominate the behavior of  $G$  at high undercoolings in bulk polymers.

- 14365.** Fickett, F. R., Sullivan, D. B., **Magnetic studies of oxidized impurities in pure copper using a SQUID system**, *J. Phys. F: Metal Phys.* **4**, No. 6, 900-904 (June 1974).

Key words: copper; impurities; magnetism; quantum interference; susceptibility.

A magnetometer system utilizing a SQUID and a superconducting flux transformer has been used to monitor the internal oxidation process in very pure copper. Both remanent moment and low field susceptibility have been measured for copper containing 0.1-1 at ppm Fe and 70 at ppm Fe in various states of anneal. The results suggest that the oxidation process proceeds quite differently in the previously unobserved situation where very dilute amounts of iron are present than in the case of relatively high impurity concentrations.

- 14366.** Lafferty, W. J., Ritter, J. J., **Microwave spectrum, structure, and dipole moment of ethynyldifluoroborane**,  $\text{H-C}\equiv\text{CBF}_2$ , *Chem. Commun.*, pp. 909-910 (1969).

Key words: dipole moment; ethynyldifluoroborane; microwave spectrum; rotational constant; structure; vibrational frequency.

The microwave spectrum of ethynyldifluoroborane was studied in the 18-33 GHz region. The molecule has been determined to have  $C_{2v}$  symmetry and estimates can be made for the C-B bond distance and the FBF angle. The dipole moment of the molecule was found to be 1.93D with a 20-uncertainty of  $\pm 0.06\text{D}$ .

- 14367.** Kohayakawa, Y., **Contrast-difference thresholds with sinusoidal gratings**, *J. Opt. Soc. Amer.* **62**, No. 4, 584-587 (Apr. 1972).

Key words: vision; visual contrast.

Two halves of a sinusoidally modulated transparency were projected on a diffusing surface. The contrast  $C$  of one half of the field was changed by defocusing until a definite difference of contrast,  $\Delta C$ , was perceived. The contrast of either half of the

field could be changed without changing the mean luminance. A plot of  $\Delta C/C$  against  $C$  declines monotonically with increasing contrast. On the other hand,  $\Delta C$  against  $C$  has a maximum at an intermediate contrast. The contrast difference  $\Delta C$  can be interpreted as relative luminance difference  $\Delta L/L$ , to which the Weber law applies. A function relating subjective to objective contrast was obtained. The relation between modulation transfer function (MTF) with constant input and constant output is discussed.

- 14368.** Rowe, J. M., Rush, J. J., Flotow, H. E., **Neutron-quasielastic-scattering study of hydrogen diffusion in a single crystal of tantalum**, *Phys. Rev. B* **9**, No. 12, 5039-5045 (June 15, 1974).

Key words: hydrogen diffusion; hydrogen in tantalum; interstitial sites; neutron scattering; quasielastic scattering; residence time; single crystal; vibration amplitudes.

The diffusion of hydrogen in a single crystal of bcc tantalum ( $\text{TaH}_{0.02}$ ) at 584 K has been investigated by neutron-quasielastic scattering at a variety of crystal orientations, and over a range of wave-vector transfer  $|\vec{Q}|$ , from 0.8 to 2.5  $\text{\AA}^{-1}$ . A detailed analysis of the observed quasielastic line shapes and widths shows that the results cannot be fitted by any simple jump-diffusion model involving instantaneous jumps between octahedral and tetrahedral interstitial sites. The quasielastic width curves (full width at half-maximum versus  $Q$ ) are much more isotropic than those predicted by any of the hydrogen-jump models, although the general shape of the widths at large  $Q$  is closer to that predicted by a tetrahedral-site model. These results are in distinct contrast to a recent neutron study of hydrogen diffusion in single-crystal (fcc) palladium, where the details of the quasielastic scattering were fitted well by a model assuming instantaneous jumps between octahedral sites. The  $\text{TaH}_{0.02}$  quasielastic peaks suggest a diffusion "relaxation time" between 1 and 2 ps at 584 K. Analysis of the data also provides an average "mean-square hydrogen vibration amplitude" of 0.040  $\text{\AA}^2$ . The present single-crystal results are in reasonable agreement with the results of a previous neutron study of polycrystalline ( $\alpha$ -phase)  $\text{TaH}_x$ . In addition, a value for the macroscopic diffusion constant at 584 K of  $2.8 \times 10^{-5} \text{ cm}^2\text{s}^{-1}$  is derived from the low- $Q$  results, which is in excellent agreement with the value predicted from Gorsky-effect measurement.

- 14369.** Hanley, H., Klein, M., Liley, P. E., Saxena, S. C., Sengers, J. V., Thodos, G., White, H. J., Jr., **Recommendations for data compilations and for the reporting of measurements of the thermal conductivity of gases**, *J. Heat Transfer*, pp. 479-480 (Nov. 1971).

Key words: critical evaluation of data; gases; thermal conductivity.

Recommendations are made with respect to what features should be incorporated in compilations of critically evaluated data to provide the greatest reliability and utility. The information required by evaluators for an accurate assessment of the reliability of experimental measurements is also discussed and some recommendations made relating to the presentation of this information.

- 14370.** Meijer, P. H. E., Scherer, W. D., **Phonons and lambda temperature in liquid  $^4\text{He}$  as obtained by the lattice model**, (Proc. 13th Int. Conf. on Low Temperature Physics, Boulder, Colo., Aug. 21-25, 1972), Paper in *Low Temperature Physics-LT 13*, K. D. Timmerhaus, W. J. O'Sullivan and E. F. Hammel, Eds., 1, 84-86 (Plenum Publ. Corp., New York, N.Y., 1974).

Key words: helium four; lambda temperature; lattice model; phonons.



This paper describes the density of the condensate in helium four from  $T = 0$  to the lambda temperature using an extension of the Matsubara Matsuda Lattice model.

- 14371.** Lilly, R. L., Rebbert, R. E., Ausloos, P., **Far ultra-violet photolysis of ammonia quantum yield determination for the primary process:**  $\text{NH}_3(\text{ND}_3) + h\nu \rightarrow \text{NH}(\text{ND}) + \text{H}_2(\text{D}_2)$ , *J. Photochem.* **2**, 49-61 (1973/74).

Key words: ammonia; extinction coefficients; far ultraviolet photochemistry; free radicals; primary processes; quantum yields.

The gas phase photolysis of  $\text{NH}_3\text{-C}_2\text{D}_4$  and  $\text{ND}_3\text{-C}_2\text{H}_4$  mixtures has been investigated at 147 nm (8.4 eV), 123.6 nm (10eV) and 104.8-106.7 nm (11.6-11.8 eV). The quantum yield of  $\text{D}_2$  in the irradiation of  $\text{ND}_3\text{-C}_2\text{H}_4$  mixtures is independent of the concentration of  $\text{C}_2\text{H}_4$  and of the pressure of  $\text{ND}_3$  (10 to 180 torr). It is concluded that in these mixtures  $\text{D}_2$  is entirely formed by molecular elimination from excited  $\text{ND}_3$ . The quantum yields of such a process are as follows at these energies: 147 nm,  $0.032 \pm 0.005$ ; 123.6 nm,  $0.244 \pm 0.01$ ; and 104.8 - 106.7 nm,  $0.306 \pm 0.007$  ( $M/N_{\text{ex}} = 0.52 \pm 0.02$ ). Although the  $\text{NH}_3\text{-C}_2\text{D}_4$  photolysis data exhibit less reliability, it can be concluded that the quantum yield of molecular  $\text{H}_2$  at 147 nm is twice that of molecular  $\text{D}_2$ . Isotope effects are much less pronounced at higher photon energies.

- 14372.** Levin, E. M., Schneider, S. J., Plante, E. R., **Phase equilibria involving seed materials in MHD**, (Proc. 13th Symp. on Engineering Aspects of Magnetohydrodynamics, Stanford University, Stanford, Calif., Mar. 26-28, 1973), Paper in *13th Symposium on Engineering Aspects of Magnetohydrodynamics*, pp. IV.5.1-IV.5.9 (Department of Mechanical Engineering, University of Mississippi, University, Miss., 1973).

Key words: alkali seeds in MHD; condensation of  $\text{K}_2\text{CO}_3$ ;  $\text{Cs}_2\text{SO}_4$ ;  $\text{Cs}_2\text{SO}_4\text{-K}_2\text{SO}_4$ ;  $\text{K}_2\text{CO}_3$ ;  $\text{K}_2\text{SO}_4$ ;  $\text{K}_2\text{CO}_3\text{-K}_2\text{SO}_4$ ;  $\text{K}_2\text{CO}_3\text{-MgO}$ ; MHD; phase equilibria.

This paper reports some of the first results in a systematic study of the phase relations involving seed materials. Polymorphism and thermal expansion of the following unary seed systems were studied by high temperature x-ray diffraction:  $\text{K}_2\text{CO}_3$ ,  $\text{K}_2\text{SO}_4$ , and  $\text{Cs}_2\text{SO}_4$ . The binary systems  $\text{K}_2\text{SO}_4\text{-Cs}_2\text{SO}_4$  and  $\text{K}_2\text{CO}_3\text{-K}_2\text{SO}_4$  were determined by DTA and high temperature x-ray diffraction. Finally, the system  $\text{K}_2\text{CO}_3\text{-MgO}$  (seed-insulator) was studied mainly by the quenching technique.  $\text{K}_2\text{CO}_3$  is dimorphic, showing a second order transition at  $420 \pm 5^\circ\text{C}$ , between the low temperature monoclinic form and the high temperature hexagonal form.  $\text{K}_2\text{SO}_4$  and  $\text{Cs}_2\text{SO}_4$  are also dimorphic, but with orthorhombic low temperature forms transforming at  $588 \pm 5^\circ\text{C}$  and  $718 \pm 5^\circ\text{C}$ , respectively, to the hexagonal phase. However, whereas the  $\text{K}_2\text{SO}_4$  transition is first order, that in  $\text{Cs}_2\text{SO}_4$  is similar to  $\text{K}_2\text{CO}_3$ , i.e., shows no volume discontinuity, and is also most likely second order. In the system  $\text{K}_2\text{SO}_4\text{-Cs}_2\text{SO}_4$ , the solidus curve shows continuous solid solution with a minimum at  $940^\circ\text{C}$  and  $\sim 50$  mol percent  $\text{Cs}_2\text{SO}_4$ . The subsolidus phase relations show a eutectoid at  $430 \pm 5^\circ\text{C}$  and  $\sim 50$  mol percent  $\text{Cs}_2\text{SO}_4$ . In the  $\text{K}_2\text{CO}_3\text{-K}_2\text{SO}_4$  system, the liquidus curve is almost horizontal near the  $\text{K}_2\text{CO}_3$  component and rises from about 25 mol percent  $\text{K}_2\text{SO}_4$ . Subsolidus solid solution phase boundaries are delineated. The  $\text{K}_2\text{CO}_3\text{-MgO}$  system, in equilibrium with its own vapor, behaves as a simple eutectic system, with the eutectic located at  $895.5^\circ\text{C}$  and  $\sim 2$  mol percent  $\text{MgO}$ . Thus, liquid will be formed anywhere in the MHD channel that condensed  $\text{K}_2\text{CO}_3$  exists in contact with  $\text{MgO}$  above  $\sim 896^\circ\text{C}$ . Thermodynamic calculations involving activity of  $\text{K}_2\text{CO}_3$  are applied to calculate approximate phase diagrams for several pressures of vaporized  $\text{K}_2\text{CO}_3$  species. Similar arguments are used to predict whether or not

liquid formation will occur in an MHD channel when additional gases are present.

- 14373.** Frederikse, H. P. R., Hosler, W. R., **Electrical conductivity of coal slag**, (Proc. 13th Symp. on Engineering Aspects of Magnetohydrodynamics, Stanford University, Stanford, Calif., Mar. 26-28, 1973), Paper in *13th Symposium on Engineering Aspects of Magnetohydrodynamics*, pp. IV.4.1-IV.4.3 (Department of Mechanical Engineering, University of Mississippi, University, Miss., 1973).

Key words: coal slag; electrical conductivity; high temperature; magnetohydrodynamics; oxides.

The efficiency of a coal fired MHD-generator will be influenced by the presence of slag layers condensed on the walls of the MHD-channel. Hence, there is a need for physical and chemical characterization of coal slags. As part of such a program, the electrical conductivity of some natural and synthetic slag samples (containing 14-36 wt. % iron) has been measured over the temperature range 1200-1700 K and at oxygen pressures between 1 and  $2 \times 10^{-6}$  atmosphere. The conductivity is relatively high ( $\sim 10^{-2} \text{ ohm}^{-1} \text{ cm}^{-1}$  at 1700 K) and stems from the transfer of electrons between ferrous and ferric ions. Anomalies in the conductivity around 1600 K are the result of devitrification of the glass samples.

- 14374.** Latanision, R. M., Ruff, A. W., Jr., **Extrinsic-intrinsic stacking-fault pairs in an Fe-Cr-Ni alloy**, *J. Appl. Phys.* **40**, No. 7, 2716-2720 (June 1969).

Key words: dislocations; electron microscopy; stacking fault energy; stacking fault pairs; stainless steel.

Transmission electron images of extrinsic-intrinsic fault pairs in a Fe-Cr-Ni alloy are shown to be sensitive to changes in the sign of  $(\mathbf{g} \cdot \mathbf{b})$ s for reflections producing either line or stacking-fault contrast. This is interpreted in terms of the overlapping strain fields of the three closely spaced partial dislocations. A differential treatment of the measured widths of the intrinsic and extrinsic faults indicates that the stacking-fault energy ratio  $\gamma_e/\gamma_i = 1.6$  in this alloy.

- 14375.** Rowe, J. M., Nicklow, R. M., Price, D. L., Zanio, K., **Lattice dynamics of cadmium telluride**, *Phys. Rev. B* **10**, No. 2, 671-675 (July 15, 1974).

Key words: cadmium telluride; frequency dispersion; lattice dynamics; neutron inelastic scattering; phonon dispersion relation; semiconductors.

The phonon dispersion relation of CdTe at 300 K has been measured for the [100], [111], and [110] directions of propagation using neutron inelastic scattering. The CdTe single crystal was grown from the melt with Cd present as  $^{114}\text{Cd}$  to reduce the neutron absorption of the specimen. The results have been fitted to a 14-parameter shell model that represents both the neutron data and other measured properties well when the non-neutron data are included in the fit. The present results, along with earlier measurements on  $\alpha\text{-Sn}$  and  $\text{InSb}$ , complete the isoelectronic sequence  $\alpha\text{-Sn} \rightarrow \text{InSb} \rightarrow \text{CdTe}$ . The systematic trends in the lattice dynamics of this series of semiconductors (which is characterized by increasing band gap and ionicity) are brought out by comparison of frequency distributions calculated from the shell-model fits.

- 14376.** Lauritzen, J. I., Jr., **Effect of a finite substrate length upon polymer crystal lamellar growth rate**, *J. Appl. Phys.* **44**, No. 10, 4353-4359 (Oct. 1973).

Key words: crystallization; growth rate; nucleation substrate; polymer.

The polymer crystal lamellar growth rate  $G$  is an often-measured property of semicrystalline polymers. In this paper, we in-



investigate the dependence of  $G$  upon the length of the substrate,  $L$ , the surface nucleation rate of new growth layers per unit length per unit time,  $i$ , the velocity with which the growth layer covers the substrate,  $g$ , and the thickness of the growth layer,  $b$ . For the purposes of this paper,  $L$  is the average length where the polymer segments in the substrate are in crystallographic register. We show that  $G = biL/\bar{n}$ , where  $\bar{n}$  is the average number of nuclei that contribute to each growth layer. We show that  $\bar{n}$  depends only on the dimensionless parameter  $z = iL^2/4g$ . We have not obtained  $\bar{n}$  explicitly, but we can place upper and lower limits on  $\bar{n}$  that closely define  $G$  in regime I, where  $G \approx biL$  and into a transition region between regime I and regime II where  $G \propto b(ig)^{1/2}$ . The experimental results for several polymers are analyzed and some are found to be in or near regime I, and others in or near regime II.

- 14377.** Burns, G. W., Hurst, W. S., Scroger, M. G., **High reliability sheathed, beryllia insulated, tungsten-rhenium alloy thermocouple assemblies—their fabrication and EMF stability**, *NASA CR-134549*, pp.1-36 (National Aeronautics and Space Administration, Washington, D.C. June 1974).

Key words: beryllium oxide; emf drift; sheathed thermocouples; tantalum; temperature measurements; tungsten-rhenium alloys.

1.6 mm diameter tantalum sheathed, BeO insulated, W-3 percent Re/W-25 percent Re thermocouple assemblies have been fabricated and their emf drift determined during 2059 hours of exposure at 2073 K in a gaseous helium environment. The sheathed thermocouple assemblies were constructed from aged thermoelements, specially heat-treated BeO insulators, and specially cleaned and etched tantalum sheaths. Their thermal emf drifts ranged from the equivalent of only  $-0.3$  to  $-0.8$  K drift per 1000 hours of exposure at 2073 K. No evidence of any gross chemical attack or degradation of the component materials was found. The emf drift and material behavior of some unsheathed, BeO insulated, W-3 percent Re/W-25 percent Re thermocouples at 2250 and 2400 K were also determined. Unsheathed thermocouples tested in an argon environment at 2250 K for 1100 hours and at 2400 K for 307 hours exhibited changes in thermal emf that typically ranged from the equivalent of a few degrees K to as much as  $+11$  K. Post-test examinations of these thermocouples revealed some undesirable material degradation and interaction which included erosion of the BeO insulators and contamination of the thermoelements by tantalum from the tantalum blackbody enclosure in which the thermocouples were contained. Preliminary tests to examine the chemical compatibility of sintered BeO insulators with Ta sheaths in an argon environment at 2073, 2250, and 2400 K were also conducted. They revealed gross erosion of the insulator after only 50 hours exposure at 2400 K. A 50 percent reduction in the insulator diameter at the open end of the sheath was typical. Well inside the sheath, where gaseous reaction products were confined, the erosion was considerably less. Similar behavior occurred with long exposure (1100 hours) at 2250 K. Serious problems with the BeO insulators were not apparent in tests at 2073 K.

- 14378.** Hoer, C. A., **The six-port coupler: A new approach to measuring voltage, current, power, impedance, and phase**, *IEEE Trans. Instrum. Meas.* **IM-21**, No. 4, 466-470 (Nov. 1972).

Key words: admittance; current; directional coupler; hybrid junction; impedance; phase angle; reflection coefficient; six-port coupler; voltage.

A six-port coupler is described having four side arms whose outputs are proportional to the voltage, current, incident voltage wave, and reflected voltage wave at some desired measurement plane in the transmission line. The phase relationship between the outputs is the same as between corresponding quantities at the measurement plane. Complex impedance and phase angle as

well as voltage, current, and power can be obtained from simple power or voltage magnitude measurements at the four side arms. A vector voltmeter used with this six-port becomes a direct reading vector impedance meter, admittance meter, or reflection coefficient meter.

- 14379.** Hudson, J., **Programming and control languages for automated laboratory experimentation**, *Astron. Astrophys. Suppl. Ser.* **15**, 487-495 (1974).

Key words: laboratory automation; process control; programming languages.

The problem of coding programs for computers used to control laboratory experiments is discussed. Several compilers which were developed for this purpose are described. The problem of developing "experimenter-proof" control languages is also addressed, and several approaches are mentioned.

- 14380.** Schwarz, F. P., Okabe, H., Whittaker, J. K., **Fluorescence detection of sulfur dioxide in air at the parts per billion level**, *Anal. Chem.* **46**, No. 8, 1024-1028 (July 1974).

Key words: detection; fluorescence;  $H_2O$ ;  $SO_2$ ; Zn lamp.

A previously reported detector capable of rapid and continuous measurement of  $SO_2$  in air has been modified to extend the detection limit to the low ppb range. The principle of detection is based on photon counting of the  $SO_2$  fluorescence excited by the Zn 2138-Å line. Fluctuation of the lamp intensity was accounted for by measuring the ratio of the fluorescence photon counts to that of the excitation source. At 8.6 ppb, the standard deviation is 29 percent for a counting time of about 1 minute. The detector response is linear from at least 8.6 ppb to 1.8 ppm. The major source of measurement error at low ppb concentrations is the statistical fluctuation of the low scattered light and signal counts, whereas at high  $SO_2$  levels, it is due to fluctuations in the sample preparation. The cell design was modified to reduce the scattered light. The inside of the cell was coated with a non-water-absorbing black Teflon to reduce possible  $H_2O$ - $SO_2$ -wall interactions. With the Zn lamp as an excitation source, the quenching effect of water vapor on the  $SO_2$  fluorescence signal previously observed with Cd 2288-Å excitation was found negligible. The result can be reasonably explained by the shorter life time of the  $SO_2$  fluorescence.

- 14381.** Hillhouse, D. L., Peterson, A. E., **A 300-kV compressed gas standard capacitor with negligible voltage dependence**, *IEEE Trans. Instrum. Meas.* **IM-22**, No. 4, 408-416 (Dec. 1973).

Key words: capacitor, compressed-gas, negligible voltage dependence; capacitor, high-voltage, negligible voltage dependence; capacitor, negligible voltage dependence; capacitor, standard, negligible voltage dependence; capacitor, 300-kV, negligible voltage dependence; voltage dependence, negligible 300-kV capacitor.

A compressed gas capacitor now in use at the National Bureau of Standards (NBS) changes capacitance by less than 2 parts per million from 0-300 kV. This extremely small variation results primarily from rugged construction, and thus requires only reasonably careful centering of its three cylindrical electrodes. It has a hollow cantilevered high-voltage electrode suspended between an outer 100-pF low-voltage electrode and a segmented inner low-voltage electrode having values of 1, 2, 4, 8, and 10 pF, or any parallel combination thereof. The capacitor's small voltage dependence was inferred from the following independent measurements: 1) comparison with another high-voltage capacitor having a small experimentally determined coefficient; 2) comparison of the inner and outer sections with each other; and 3) measurement of capacitance change resulting from application of known forces on the cantilevered electrodes, and correlating



this with calculated high-voltage electrostatic forces. The capacitor is used in determining the voltage coefficients of NBS-owned commercial standard capacitors; in the calibration of customers' standard capacitors, voltage transformers, and dividers to 200 kV and above; and in research on coupling capacitor voltage transformers and other high-voltage devices and materials.

- 14382.** Lovas, F. J., Johnson, D. R., **Microwave spectrum of BF**, *J. Chem. Phys.* **55**, No. 1, 41-44 (July 1, 1971).

Key words: boron monofluoride; dipole moment; discharge; microwave spectrum; quadrupole structure; rotational transitions; transient species.

Direct rotational transitions have been observed in the ground vibrational state of  $^{10}\text{B}^{19}\text{F}$  and  $^{11}\text{B}^{19}\text{F}$  produced in the gas phase by a discharge in flowing  $\text{BF}_3$ . Measurements on the  $J=1 \leftarrow 0$  transitions yield  $B_0(^{10}\text{BF}) = 48\,022.63 \pm 0.08$  MHz,  $eq_0Q(^{10}\text{B}) = -9.5 \pm 0.8$  MHz,  $B_0(^{11}\text{BF}) = 45\,185.77 \pm 0.06$  MHz, and  $eq_0Q(^{11}\text{B}) = -4.5 \pm 0.4$  MHz. New molecular parameters are derived for  $^{11}\text{BF}$  including  $B_e = 45\,481$  MHz, and  $r_e = 1.2625$  Å. The electric dipole moment of BF is determined to be  $0.5 \pm 0.2$  D.

- 14383.** Seltzer, S. M., Berger, M. J., **Transmission and reflection of electrons by foils**, *Nucl. Instrum. Methods* **119**, 157-176 (May 1974).

Key words: angular distribution; electrons; energy spectra; reflection; transmission; transport calculation.

This paper describes Monte Carlo calculations pertaining to the penetration of electron beams through foils. The method of calculation is validated by comparisons with experimental transport data at energies between 50 keV and 1 MeV. New data are presented on the transmission and reflection of electrons through beryllium, mylar, aluminum, and titanium foils, for incident beam energies between 100 and 400 keV. The results given include transmission and reflection coefficients and the energy spectra and angular distributions of transmitted electron beams.

- 14384.** Heinrich, K. F. J., Barrett, C. S., Newkirk, J. B., Ruud, C. O., Eds., **Advances in x-ray analysis**, *Proc. 20th Annual Conf. on Applications of X-Ray Analysis*, Aug. 11-13, 1971, **15**, 573 pages (Plenum Press, New York, N.Y., 1972).

Key words: automation; defraction; detectors; spectrometry; x-ray analysis; x-ray fluorescence.

The application of solid-state detectors of high energy resolution to x-ray spectrometry, and the increasing use of computers in both measurement and data evaluation, are giving a new stimulus to x-ray techniques in analytical chemistry. The Twentieth Annual Denver X-Ray Conference reflects this renewed interest in several ways.

The invited papers, grouped in Session I, review the characteristics of the detectors used in the measurement of x rays. One paper is dedicated to the detection of single ions. Although such a subject may appear to be marginal to the purposes of the Denver Conference, we must recognize the affinity of techniques applied to similar purposes. Ion probe mass spectrometry is dedicated to tasks similar to those performed by x-ray spectrometry with the electron probe microanalyzer. Scientists and technologists will see these two techniques discussed in the same meetings.

The discussion of automation and programming is not limited to the two invited speakers, but extends to papers presented in more than one session. The matter of fluorescence analysis by isotope- and tube-excitation will also be of great interest to those concerned with the practical applications of x-ray techniques.

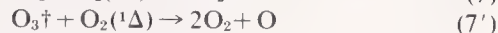
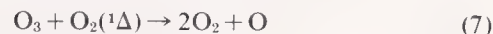
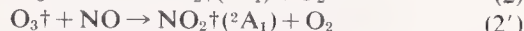
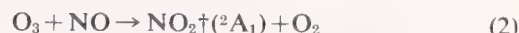
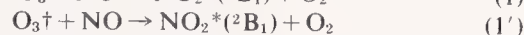
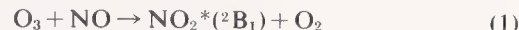
The communications contained in this volume, and the lively discussions which frequently followed the presentation of

papers, attest to the vitality of the subjects which are the concern of the Annual Denver X-Ray Conference.

- 14385.** Kurylo, M. J., Braun, W., Kaldor, A., Freund, S. M., Wayne, R. P., **Infrared laser enhanced reactions: Chemistry of vibrationally excited  $\text{O}_3$  with NO and  $\text{O}_2(^1\Delta)$** , *J. Photochem.* **3**, 71-87 (1974/75).

Key words: kinetics; laser enhanced reactions; nitric oxide;  $\text{O}_2(^1\Delta)$ ; ozone; vibrationally energy.

Vibrationally excited ozone, produced by absorption of  $\text{CO}_2$  laser radiation, was found to react significantly faster with NO and  $\text{O}_2(^1\Delta)$  than thermal ozone. Using a modulation technique, absolute and relative rate constants at 300 K for the following reactions were calculated assuming rapid equilibration between the three closely spaced vibrationally excited levels of  $\text{O}_3$ , and that only the lowest level of these, the  $\nu_2$  bending mode, is active in reaction.



$k_{1'} + k_{2'} = 2.7 \times 10^{-13}$  cm<sup>3</sup> molecule<sup>-1</sup> s<sup>-1</sup>;  $(k_{1'} + k_{2'})/(k_1 + k_2) = 16.2 \pm 4.0$ ;  $k_{1'}/k_1 = 4.1 \pm 2.0$ ;  $k_{2'}/k_2 = 17.1 \pm 4.3$ ;  $k_{7'}/k_7 = 38 \pm 20$ . These rate constants must be modified if a different combination of vibrationally excited levels is involved. The fraction of vibrational energy usable in chemical reaction was found to be about 15, 50 and  $\sim 100$  percent respectively for processes 1', 2' and 7'. Our measurements clearly differentiate between the participation of vibrational energy and thermal energy but do not distinguish differences between the individual vibrationally excited states. Details of the modulation technique, involving chemiluminescence detection of  $\text{NO}_2$  and resonance fluorescence detection of oxygen atoms, are described. Comparison of our results with a previous measurement of the summation reaction  $(1' + 2')$  shows excellent agreement.

- 14386.** Dorman, D. E., Torchia, D. A., Bovey, F. A., **Carbon-13 and proton nuclear magnetic resonance observations of the conformation of poly(L-proline) in aqueous salt solutions**, *Macromolecules* **6**, No. 1, 80-82 (Jan.-Feb. 1973).

Key words: carbon-13; nuclear magnetic resonance; poly-L-proline; polypeptides.

Proton nmr at 220 MHz and  $^{13}\text{C}$  nmr at 25 and 15.08 MHz have been employed to confirm previous conclusions that the disordering of poly(L-proline) chains in concentrated aqueous salt solutions arises primarily from the formation of random sequences of cis and trans peptide bonds. The effects of KI and  $\text{CaCl}_2$  are essentially similar. The  $\beta$ - and  $\gamma$ -carbon resonances of the proline ring appear to be the most reliable monitors of this isomerization process, giving distinct and well resolved peaks for the cis and trans conformations.

- 14387.** Jackson, R. H. F., Lechner, J. A., Sookne, D. J., **A system for position-location based on ranges**, (Proc. 18th Conf. on the Design of Experiments in Army Research Development and Testing, Aberdeen Proving Ground, Md., Oct. 25-27, 1972), *ARO Report 73-2*, Part 2, 549-577 (Department of Defense, Washington, D.C., 1973).

Key words: algorithms; least-squares; multilateration; position-location; ranges; simulation.

The system in question is intended to employ range-only information, or range-plus-altitude information, to track the positions



of up to hundreds of users (only some of which measure ranges to other users) in three dimensions or on the earth's surface. This paper describes the structure, use and results of a simulation study which focused, within a larger analysis, on the absolute and relative adequacies of various mathematical position-estimation algorithms. The discussion will include comparisons among the six different algorithms investigated, considering both accuracy and computer time required.

- 14388.** Hayward, R. W., Parity, Paper in *The Encyclopedia of Physics*, 2d Edition, R. M. Besancon, Ed., pp. 671-675 (Van Nostrand Reinhold Co., New York, N.Y., 1974).

Key words: charge conjugation; parity; relativity; space inversion; time reversal.

A short encyclopedic article on the concept of parity and other discontinuous Lorentz transformations and their applications in physics.

- 14389.** Fanconi, B., Lattice dynamics of polyglycine I, *J. Chem. Phys.* **57**, No. 5, 2109-2116 (Sept. 1, 1972).

Key words: frequency distribution; lattice vibrations; normal mode analysis; polyglycine I.

The two-dimensional lattice vibrations of the extended form of polyglycine have been calculated from a five mass model of the glycine chemical repeat unit and with interchain hydrogen bond stretching. The effects of hydrogen bond bending and torsion on the lattice modes are determined using a model in which the entire chemical repeat unit is treated as a single dynamical unit. The valence force field for the latter model is found by fitting the optical frequencies determined from the five mass calculation. The density of phonon states for the two-dimensional lattice is determined for the single mass model.

- 14390.** Brower, W. S., Minor, D. B., Parker, H. S., Roth, R. S., Waring, J. L., Flux synthesis of cubic potassium antimonate, *Mater. Res. Bull.* **9**, No. 8, 1045-1051 (1974).

Key words: cubic potassium antimonate; flux synthesis; impurity stabilization; potassium antimonate; potassium fluoride-antimony oxide; single crystals.

Although the compound  $\text{KSbO}_3$  has been reported to occur in a high temperature cubic polymorph, only the rhombohedral ilmenite phase was obtained in this study for pure material at ambient pressure and temperatures up to about 1350 °C in open Pt crucibles or sealed Pt tubes. With the addition of about 2 mole percent  $\text{SiO}_2$ ,  $\text{B}_2\text{O}_3$  or other oxides of small cations a primitive cubic phase was found with  $a \approx 9.578$  Å. Small single crystals of a body centered cubic phase ( $a = 9.605$  Å) were easily synthesized by a flux evaporation technique at about 1000 °C in an open Pt crucible from a composition of about 5 mole percent  $\text{Sb}_2\text{O}_4$ :95 mole percent KF. The exact composition and structure of this phase (presumably  $\text{K}_{1-x}\text{SbO}_{3-x}\text{F}_x$ ,  $0 < x \leq 0.5$ ) is now under investigation.

- 14391.** Kuriyama, M., Early, J. G., The dynamical scattering amplitude of an imperfect crystal. III. A dynamical diffraction equation for topography in the spatial coordinate representation, *Acta Crystallogr.* **A30**, 525-535 (Jan. 1974).

Key words: dynamical diffraction; imperfect crystal; integral equation; topography.

Based on a general dynamical theory of diffraction, an integral equation for dynamical diffraction in imperfect crystals is obtained in the spatial coordinate representation. This equation is derived for diffraction topography in the symmetrical Laue geometry from the basic dynamical equation of diffraction previously derived in the momentum representation. Discussion is presented on an interpretation of this integral equation beyond

the given diffraction geometry. This equation can be considered as a basic equation for diffraction topography.

- 14392.** Hockey, B. J., Use of the hardness test in the study of the plastic deformation of single crystals, (Proc. ASM-AIME Symp. on the Science of Hardness Testing and its Research Applications, Detroit, Mich., Oct. 18-21, 1971), Chapter 3 in *The Science of Hardness Testing and its Research Applications*, pp. 21-50 (American Society for Metals, Metals Park, Ohio, 1973).

Key words: deformational twinning; dislocations; hardness test; lattice friction; plastic deformation; single crystals.

The use of the hardness test in the study of the plastic deformation of single crystals is reviewed and its applicability to materials of different mechanical behavior discussed. Emphasis is placed on those studies which demonstrate the unique or relative advantages of point loading. It is shown that valuable information on the conditions under which plastic flow occurs, on dislocation slip system identification, on deformational twinning, and on lattice friction effects have been obtained.

- 14393.** Heuer, A. H., Cannon, R. M., Tighe, N. J., Plastic deformation in fine-grain ceramics, (Proc. 15th Sagamore Army Materials Research Conf., Sagamore Conference Center, Raquette Lake, N.Y., Aug. 20-23, 1968), Chapter 16 in *Ultrafine-Grain Ceramics*, pp. 339-365 (Syracuse University Press, Syracuse, N.Y., 1970).

Key words: fine-grain ceramics; grain boundary; plastic deformation; polycrystalline.

Plastic deformation in fine-grain (i.e.,  $\leq 10 \mu$ ) ceramics is discussed. It is shown that fine-grain polycrystals can be exceptionally ductile, the fine grain size enhancing diffusional deformation and grain boundary sliding processes. The deformation is sensitive to both grain size and temperature.

The influence of grain size ( $1-10 \mu$ ), strain-rate ( $2 \times 10^{-6} - 3 \times 10^{-4}$ /sec), and temperature (1100-1700 °C) on the deformation of fine-grain alumina has been studied. It is suggested that the predominant deformation mechanism in the larger grained polycrystals is diffusional creep, and that grain boundary sliding makes an increasingly important contribution as the grain size is decreased; in addition, deformation twinning can also be important. These results are shown to be consistent with previous work on deformation in polycrystalline alumina. A brief review of the literature on plastic deformation in fine-grain magnesia, beryllia, thoria, and urania indicates that grain boundary sliding may be important for each of these materials as well.

- 14394.** Ku, H. H., Statistical methods applicable to counting experiments and evaluation of experimental data, *Nucl. Instrum. Methods* **112**, 377-383 (1973).

Key words: calibration; check standard; control chart on precision measure; data analysis; design of experiments; reporting of results; standards; statistical methods.

In an experiment a sequence of operations is performed that results in the collection, interpretation, and transmission of information on a topic of interest. Statistical methodology may be used to help in increasing the efficiency of collection, in checking the validity of interpretation, and in editing the presentation of results. Some such concepts and methods that are useful to counting experiments, and essential to the operations of standards and calibration laboratories, will be discussed.

- 14395.** Lieblein, J., Generalized propagation of error using a new approach, *Proc. 11th Annual Meeting of the Institute of Nuclear Materials Management, Gatlinburg, Tenn., May 25-27, 1970*, pp. 190-211 (1970).



Key words: coefficients subject to error; determinant; error propagation; implicit functions; linear equations; matrix; propagation of error; variance.

Propagation of error formulas for the case of one function of several variables or several explicitly known functions have been studied. The only untreated case remaining is the one where the "dependent" variable is an implicit function and cannot readily (or at all) be solved in terms of the independent variables. This case is treated in the present paper which takes the general matrix viewpoint and thereby obtains results in concise form. A special case is application to linear (algebraic) system, arising in an idealization of a nuclear process flow, without the necessity for obtaining the explicit solution.

- 14396.** Gallagher, A., Lewis, E. L., **Resonance broadening of Hanle-effect signals in rubidium**, *Phys. Rev. A*, **10**, No. 1, 231-241 (July 1974).

Key words: line broadening; rubidium.

We have measured the broadening of  $\text{Rb}^{87}$  level-crossing signals due to collisions with  $\text{Rb}^{85}$ . The depolarization or broadening rates for the  $5^2P_{1/2}$  state orientation, the  $5^2P_{3/2}$  state orientation and alignment, and the  $5^2P_{3/2}$  state 58-G crossing were measured. Theoretical resonance-broadening depolarization rates for the electronic angular momentum, due to Carrington, Stacey, and Cooper, have been incorporated into calculations of the Hanle-effect signals in the presence of nuclear-spin coupling. The experimental broadening rates are corrected for a minor amount of coherence narrowing. The measured broadening rate for the three  $5^2P_{1/2}$  state level-crossing signals are in 20 percent agreement with the theory. The measured  $5^2P_{1/2}$  state broadening rate exceeds the theoretical by about a factor of 2. This discrepancy may be due to the action of the hyperfine interaction during these unusually long duration collisions. The natural lifetimes of the  $5^2P_{3/2}$  and  $5^2P_{1/2}$  states are determined from the low-density linewidth to be  $27.0 \pm 0.5$  and  $29.4 \pm 0.7$  nsec, respectively.

- 14397.** Kaldor, A., Hastie, J. W., **Infrared laser modulated molecular beam mass spectrometry**, *Chem. Phys. Lett.* **16**, No. 2, 328-331 (Oct. 1, 1972).

Key words: infrared laser; laser chemistry; mass spectrometry; molecular beam; phase spectroscopy; vibrational energy transfer.

A technique is described whereby a modulated molecular beam can be extracted from gas mixtures which are excited by infrared laser radiation. The method has been applied to time resolved mass spectrometric studies of laser induced molecular processes for systems containing  $\text{BCl}_3$  and  $\text{SF}_6$  as radiation absorbers, and shows general applicability to studies of laser induced chemical reaction.

- 14398.** Khoury, F., Fanconi, B., Barnes, J. D., Bolz, L. H., **Effects of polymorphism on the Raman-active longitudinal acoustical mode frequencies of *n*-paraffins**, *J. Chem. Phys.* **59**, No. 11, 5849-5857 (Dec. 1, 1973).

Key words: chain-folded polyethylene crystals; longitudinal acoustical modes; *n*-paraffins; polymorphism; Raman spectroscopy.

Raman spectroscopic measurements on the orthorhombic and monoclinic crystalline forms of  $n\text{-C}_{36}\text{H}_{74}$  and  $n\text{-C}_{94}\text{H}_{190}$  show that the frequencies of the longitudinal acoustical modes depend on the orientation of the chain axis relative to the planes containing the terminal methyl groups as well as the chain length. The frequency differences between the orthorhombic and monoclinic forms of a given *n*-paraffin depend on the magnitude and direction of the regular stagger between neighboring end groups in the monoclinic forms. It is concluded that these frequency dif-

ferences are most likely associated with variations in end group packing associated with differences in crystalline form. The implications of these observations to the use of Raman spectroscopic data to characterize the morphology of chain-folded polyethylene crystals are discussed.

- 14399.** Halford, D., **Comparing frequencies**, *Phys. Today* **26**, No. 2, 15 (Feb. 1973).

Key words: cesium frequency; frequency multiplication; infrared frequency synthesis; Josephson junction; lasers; methane frequency.

An incorrect and misleading statement was made in a news item in Physics Today, April 1972, page 17, regarding infrared frequency synthesis: "A chain of experiments is needed because two frequencies differing by more than a factor of 12 cannot be compared directly." This Letter to the Editor points out the existence and importance of some previously published papers, including as examples factors of 100 and of 401 obtained in one direct step, respectively, by McDonald and coworkers in 1970 and in 1971.

- 14400.** LaVilla, R. E., **Semi-Auger electron transitions**, (Proc. Int. Conf. on Inner Shell Ionization Phenomena and Future Applications, Atlanta, Ga., Apr. 17-22, 1972), Paper in *Proceedings of the International Conference on Inner Shell Ionization Phenomena and Future Applications*, R. W. Fink, S. T. Manson, J. M. Palms, and P. V. Rao, Eds., Conf. 720404, 1, 509-522 (U.S. Atomic Energy Commission, Technical Information Center, Oak Ridge, Tenn., Jan. 1973).

Key words: argon, KCl,  $\text{CH}_3\text{Cl}$ ,  $\text{SF}_6$ ; L and K x-ray spectra; semi-Auger effect; x-ray photoelectron spectra.

The argon and KCl  $\text{L}_{2,3}$  x-ray emission spectra excited by direct electron bombardment have been recorded with photon counting on a planar single crystal spectrometer. A prominent feature lying approximately 6, 11, and 14 eV below the parent emission peak in Cl, Ar and K respectively, was observed in the spectra. Comparison with other data on related processes indicates that the low energy features are direct evidence of a "semi-Auger" two electron process, due to configuration interaction in the final state. The initial  $\text{L}_{2,3}$  single vacancy is filled by an outer shell electron and simultaneously another outer shell electron is excited with the emission of a single photon. The possible identification of this process in other systems will also be discussed.

- 14401.** Kranbuehl, D. E., Verdier, P. H., **Monte Carlo studies of the relaxation of vector end-to-end length in random-coil polymer chains**, *J. Chem. Phys.* **56**, No. 6, 3145-3149 (Mar. 15, 1972).

Key words: end-to-end length; Monte Carlo; polymer chain dynamics; random-coil.

The effects of excluded volume interactions upon the dynamical behavior of random-coil polymer chains are studied by obtaining autocorrelation functions for vector end-to-end length of lattice-model chains of 9, 15, 33, and 63 beads by a Monte Carlo simulation technique. It is found that relaxation of the vector end-to-end length requires from 4 to 7 times as long as relaxation of its square, in contrast to the predictions of simple models without excluded volume effects.

- 14402.** Jacob, E. J., Lide, D. R., Jr., **Microwave investigation of methyl sulfone and methane sulfonyl fluoride**, *J. Chem. Phys.* **54**, No. 11, 4591-4596 (June 1, 1971).

Key words: dipole moment; internal rotation; methane sulfonyl fluoride; methyl sulfone; microwave spectra; molecular structure.



Rotational constants for the ground state of methyl sulfone and for the ground and first excited torsional state of methane sulfonyl fluoride have been derived from microwave spectra observed in the 18 000 – 37 000-MHz region. Molecular dipole moments of  $4.50 \pm 0.10$  D for  $(\text{CH}_3)_2\text{SO}_2$  and  $3.88 \pm 0.04$  D for  $\text{CH}_3\text{SO}_2\text{F}$  were measured. Relative intensity measurements place the barrier to methyl rotation in  $\text{CH}_3\text{SO}_2\text{F}$  at  $880 \pm 120$   $\text{cm}^{-1}$  ( $2.25 \pm 0.35$  kcal/mole). Alternate structures for  $(\text{CH}_3)_2\text{SO}_2$ , based on assumption of either the SO or the SC bond length from a recent electron diffraction study, are presented. Both reveal a significant discrepancy between the microwave and diffraction values for the OSO angle.

**14403.** Giguere, P. T., Clark, F. O., Snyder, L. E., Buhl, D., Johnson, D. R., Lovas, F. J., **Upper limits for interstellar fulvene and nitric acid**, *Astrophys. J.* **182**, No. 2, 477-479 (June 1, 1973).

Key words: fulvene; interstellar molecules; nitric acid; radio astronomy; rotational transitions; telescope search.

Radio searches for the  $1_{01}-0_{00}$  transition of fulvene (an isomer of benzene) at 6399 MHz and for the  $1_{10}-1_{11}$  transition of nitric acid at 5839 MHz were not successful. Upper limits are reported for fulvene against three galactic sources and for nitric acid against four. Our measurements indicate that nitric acid may be underabundant with respect to cyanoacetylene in the direction of Sgr B2.

**14404.** Lauritzen, J. I., Jr., Zwanzig, R., **Exact calculation of the partition function for a generalized model of two-dimensional polymer crystallization by chain folding**, *J. Chem. Phys.* **52**, No. 7, 3740-3751 (Apr. 1, 1970).

Key words: chain-folded crystal; partition function; phase transition; polymer.

A generalized model for two-dimensional polymer crystallization by chain folding is treated by equilibrium statistical mechanics. A generating function for the partition function is obtained in exact analytic form. The model leads to thermodynamically well-defined chain-folded polymer crystals. Under certain circumstances in the limit of an infinitely long polymer chain, the model shows a second-order phase transition from an "extended-chain" crystal to the chain-folded crystal.

**14405.** Sengers, J. M. H. L., **From Van der Waals' equation to the scaling laws**, *Physica* **73**, 73-106 (1974).

Key words: coexistence curve; corresponding states; critical exponents; critical isotherm; rectilinear diameter; scaling laws; scaling symmetry; universality; Van der Waals' equation; vapor pressure curve.

From our present-day perspective, the most important results obtained by Van der Waals for thermodynamic behavior in the critical region of gases are: the cubic critical isotherm and quadratic coexistence curve; the continuity of slope of the vapor-pressure curve; the law of the rectilinear diameter and the law of corresponding state. The critical behavior of Van der Waals' equation is typical for equations of state that are regular at the critical point in a sense to be discussed; those equations are presently called "classical." The confrontation with experiment took place before 1900. At that time, the first power-law analyses of data were made and their results disproved classical theory convincingly. It took, however, another 65 years before classical theory was replaced by the scaling laws. The very limited validity of the law of corresponding states, however, never posed a serious threat to the classical equation. On the contrary, by generalizing this law in various ways, our insight into the relation between molecular interaction and thermodynamic behaviour has been deepened considerably. In a sense, the principle of universality may be considered the latest generalization of the law of corresponding states. The principle

of continuity of slope of the vapor-pressure curve has been preserved; the direction of the vapor-pressure curve at the critical point is a very special one according to the thermodynamic theory of Wheeler and Griffiths and also in the theories of "extended scaling." The law of the rectilinear diameter, now under siege by theory, has not yet failed us experimentally.

The lines from the past to the present are sketched in this contribution, and the modern concepts of scaling will be developed from the classical equation of state. The consequences of the scaling laws for the description of thermodynamic data of fluids in the critical region will be discussed and illustrated with experimental material. Universality of critical behavior in fluids will be demonstrated.

**14406.** Mann, D. B., **ASRDI oxygen technology survey. Volume VI: Flow measurement instrumentation**, *NASA Spec. Publ.* **3084**, 104 pages (National Aeronautics and Space Administration, Washington, D.C. 1974).

Key words: argon; calibration; cryogenic; flowmeter, measurement; nitrogen; oxygen.

A survey of the literature combined with the results of a joint government-industry cooperative program on cryogenic flowmetering is presented. The objective was to establish the state of the technology and art of oxygen flowmetering in liquid and gaseous states.

Only those meters with demonstrated performance are considered. These were classified as quantity, head, momentum and velocity types. A comparison of the performance of these devices and a discussion of future requirements for flow reference systems and metering are given.

**14407.** Malmberg, M. S., Maryott, A. A., **Dipole moments of  $\text{ClSF}_5$  and  $\text{CF}_3\text{SF}_5$  from the dielectric relaxation spectra of the vapors**, *J. Chem. Phys.* **53**, No. 4, 1614-1615 (Aug. 15, 1970).

Key words:  $\text{CF}_3\text{SF}_5$ ;  $\text{ClSF}_5$ ; dielectric relaxation time; dipole moment; microwave absorption; vapor phase.

The microwave absorption associated with the dielectric relaxation spectra of the symmetric-top gases,  $\text{ClSF}_5$  and  $\text{CF}_3\text{SF}_5$ , was measured at various pressures up to two atmospheres at a frequency of 1216 MHz at 298 K. Values of the electric dipole moments derived from these data are 0.51<sub>1</sub> D for  $\text{ClSF}_5$  and 0.38<sub>4</sub> D for  $\text{CF}_3\text{SF}_5$ .

**14408.** Martin, W. C., **Low-energy level structure of neutral cerium (Ce I)**, *Phys. Rev. A* **3**, No. 6, 1810-1815 (June 1971).

Key words: atomic energy levels; atomic spectra; electron configurations; neutral cerium; Zeeman effect.

The low portion of an extensive level structure derived from analysis of the optical spectrum is reported. Positions,  $J$  values, and  $g_J$  factors are given for 98 levels, including all 91 levels expected below 10 000  $\text{cm}^{-1}$ . A previous report on this analysis showed the ground level to be  $4f^5d6s^2\ ^1G_4^\circ$  and gave the lowest levels of  $4f^5d^26s$ . Comparison of the observed odd-parity levels with calculations by Goldschmidt and Salomon shows that all 86 of the odd levels tabulated here belong to these configurations. All but seven of these odd levels are assigned  $LS$  names, although the calculations show that many of them have low  $LS$  purities, and a few have strong mixtures of the two configurations. The much simpler system of even levels below 10 000  $\text{cm}^{-1}$  includes only the six levels of  $4f^26s^2\ ^3H$  and  $^3F$ , beginning with  $^3H_4$  at 4762.718  $\text{cm}^{-1}$  above the ground-state level. The table of even levels also includes  $4f^26s^2\ ^1G_4$  and the lowest two levels of each of the lowest two terms of  $4f^25d6s$ ,  $^3F_{4,5}$ , and  $^5K_{5,6}$ .

**14409.** Layer, H. P., **Circuit design for an electronic self-nulling ellipsometer**, *Surface Sci.* **16**, 177-192 (1969).



**Key words:** corrosion; electronic ellipsometer; Faraday cells; self-nulling ellipsometer; thin films.

The importance of automating the ellipsometer has been recognized by researchers active in the field and considerable attention has been given to the development of a practical instrument. The present work was motivated by the belief that a more satisfactory automatic ellipsometer could be developed if the all-electronic approach suggested by Winterbottom was used. This approach has resulted in the design and construction of an instrument that is sensitive, stable, relatively inexpensive and which has a response time that is of the order of milliseconds. The electronic circuits will easily lend themselves to duplication by investigators interested in such a device and are of such a configuration that existing instruments need only minor modifications. An automatic gain stage circuit is included to maintain maximum sensitivity where spectral emission and sensitivity variations are encountered, as in continuous wavelength scanning ellipsometric measurements.

**14410.** Mahoney, R., Srinivasan, G. R., Macedo, P. B., Napolitano, A., Simmons, J. H., **Effect of subcritical microstructure on the viscosity of a sodium borosilicate glass**, *Phys. Chem. Glasses* **15**, No. 1, 24-31 (Feb. 1974).

**Key words:** borosilicate; environmental-relaxation model; glass; microstructure; phase-separation; viscosity.

Viscosity and electron microscopy measurements were made on a phase separating glass as a function of time, at various temperatures. The viscosity changed by five orders of magnitude during the phase separation in a time period identified to be solely in the coarsening stage by electron microscopy. The stage during which composition changes are dominant occurs very quickly despite the high starting viscosity ( $10^{11}$  P) and, therefore, is nearly complete before reliable viscosity data can be obtained (2 min). Analysis of the rate of increase of the average particle size identified a rearrangement stage proceeding by bulk diffusion through the fluid phase with an apparent activation energy of 98 kcal/mole ( $4.1 \times 10^5$  J/mole). Superposition of the viscosity-microstructure size curves for various temperatures demonstrated that the change in viscosity was totally controlled by the growth of the viscous phase whose activation energy for viscosity is 132 kcal/mole ( $5.52 \times 10^5$  J/mole). The change of viscosity with time is explained in terms of changes in the size of the microstructure by applying an environmental relaxation model proposed by two of the authors. The significance of the good quantitative fit of the data by the model and the physical significance of the parameters are discussed.

**14411.** McClendon, L. T., DeVoe, J. R., **Substoichiometric radioisotope dilution analysis of tungsten as a major constituent in molybdenum containing materials using toluene-3,4-dithiol**, *Anal. Chem.* **41**, No. 11, 1454-1456 (Sept. 1969).

**Key words:** molybdenum; radioisotope dilution; substoichiometric; toluene-3,4-dithiol; tungsten.

A radioisotope dilution procedure was developed for tungsten determination in molybdenum containing materials using a substoichiometric amount of the complexing reagent, toluene-3,4-dithiol. Using this approach, an equal amount of tungsten is isolated before and after dilution of the radioisotope, thus avoiding serious interferences by eliminating the need for quantitative separation. This technique was used for tungsten determination in NBS tungsten-molybdenum alloy (SRM-480) indicate composition of alloy found by standard method where the average concentration found was 79.32 percent with a pooled estimate of the standard deviation (for a single determination) of  $\pm 0.43$  percent. The precision obtained is very good for this type of technique.

**14412.** Miller, L. D., Schima, F. J., **The half-life of  $^{129m}\text{Xe}$** , *Int. J. Appl. Radiat. Isotop.* **24**, 353 (1973).

**Key words:** gamma-ray energy; half-life; isomeric  $^{129}\text{Xe}$ ; radioactivity; transition probability.

The decay of the isomeric level in  $^{129}\text{Xe}$  has been studied by means of Ge(Li) and Si(Li) detectors. Sources of the isomeric activity were prepared by (n, $\gamma$ ) reaction on isotopically enhanced  $^{129}\text{Xe}$  ion implanted in Al foil. Two  $\gamma$ -rays have been observed. The energies and estimated standard errors were found to be  $39.50 \pm 0.17$  and  $196.46 \pm 0.02$  keV. The isomeric half-life and estimated standard error have been determined to be  $8.89 \pm 0.02$  days. The reduced transition probabilities of the four M4 isomers of Xe are compared to the quasiparticle theory.

**14413.** Hastie, J. W., **Mass spectrometric evidence for  $\text{HO}_2$  in 1 atm flames**, *Chem. Phys. Lett.* **26**, No. 3, 338-343 (June 1, 1974).

**Key words:** flame inhibition; flames;  $\text{HO}_2$ ; mass spectrometry.

The perhydroxyl species  $\text{HO}_2$  has been observed in 1 atm  $\text{H}_2 - \text{O}_2 - \text{N}_2$  flames and its flame concentration determined as a function of flame composition and position. Also the oxidation of small additions of CO to these flames has been observed and the results favor the reaction,  $\text{OH} + \text{CO} \rightarrow \text{CO}_2 + \text{H}$ , rather than the alternative process,  $\text{HO}_2 + \text{CO} \rightarrow \text{CO}_2 + \text{OH}$ .

**14414.** Molino, J. A., **Equal aversion levels for pure tones and 1/3-octave bands of noise**, *J. Acoust. Soc. Amer.* **55**, No. 6, 1285-1289 (June 1974).

**Key words:** audition; aversion for sound; escape and avoidance; loudness; noisiness; psychophysics; schedules of reinforcement.

College students tapped rapidly on a telegraph key to reduce the intensity of a continuous acoustic stimulus presented through earphones. Failure to respond resulted in an intensity of 1 dB every 4 sec. A group of 14 students responded during 10-min sessions to eight pure tones and eight 1/3-octave bands of noise at octave frequencies from 63 Hz to 8 kHz. The average SPL maintained by the subjects became stable after about 5 min. The different asymptotic levels observed from 5-10 min were taken as a measure of equal aversion levels for the stimuli. Equal aversion levels were compared with other subjective weighting contours: equal loudness level, A-weighted sound level, perceived noise level, etc. They were closest to an A-weighted sound level of 80-85 dB.

**14415.** Marezio, M., Dernier, P. D., Santoro, A., **Twinning in Cr-doped  $\text{VO}_2$** , *Crystallogr.* **A29**, 618-621 (1973).

**Key words:** chromium doping; metal-insulator transitions; twinning; vanadium oxide; x rays.

Twinning has been studied in several samples of  $\text{VO}_2$  containing substitution solid solution 0.5 and 2.5 at.% Cr. The twinning is by reticular pseudo-merohedry and it is controlled by the tetragonal pseudo-symmetry of a superlattice obtained from the original monoclinic cell ( $a \approx 9.1$ ,  $b \approx 5.8$ ,  $c \approx 4.55$  Å,  $\beta \approx 90$ ) by means of the transformation 100/002/010. More than one twin law is found in every sample studied. All the theoretically possible twin laws, except one, have been observed. The possibility of twinning simulating a lattice and a space group different from the true ones has been pointed out and methods for detecting twins in these cases are given.

**14416.** Santoro, A., **Characterization of twinning**, *Acta Crystallogr.* **A30**, Part 2, 224-231 (Mar. 1974).

**Key words:** coincidence-site lattices; determination of twin laws; equivalence of twin laws; lattices; oriented crystal growths; twin obliquity and twinning.

A new twinning condition is derived. It is more general than Friedel's ratios [Friedel, G. (1964). *Leçons de Cristallographie*, p. 249, Paris: Blanchard], and it allows one to predict not only



the twin laws of a crystalline species, but also the regular associations of crystals mutually oriented according to noncrystallographic rotations. The deviation suffered by the twin lattice at the composition surface is better described in terms of the new twinning condition than in terms of the twin obliquity.

**14417.** Molino, J. A., **Odor pollution detection and measurement**, *ASTM Stand. News Letter to Editor* **1**, No. 3, 47 (Mar. 1973).

Key words: pollution; psychophysics.

This paragraph proposes the organization of a committee, task force, or working group to study psychophysical measurement techniques and data concerning human tolerance to and permissible standards for various sorts of pollution, e.g., odor, noise, glare, vibration, etc.

**14418.** Kunasz, P. B., Hummer, D. G., **Radiative transfer in spherically symmetric systems-IV. Solution of the line transfer problem with radial velocity fields**, *Mon. Notic. Roy. Astron. Soc.* **166**, No. 1, 57-78 (1974).

Key words: gas dynamics; radiative transfer; spectral line profiles; stellar atmospheres.

A numerical procedure is presented for solving the line transfer problem with complete redistribution in spherically symmetric atmospheres in which the radial velocity is an arbitrary function of radius, limited by practical considerations to maximum velocities a few times the mean thermal velocity. In this procedure the transfer equation, written in the observer's frame, is differenced along rays and the resulting very large set of coupled linear equations is cast into the novel form, proposed by Rybicki, that allows for extremely rapid solution of the system. Numerical results are discussed for three sequences of models, two with linear velocity laws and one with constant velocities, in which the effect of the transverse velocity gradient is demonstrated. It is shown that velocities as small as 0.05 of the mean thermal velocity produce observable asymmetries in the flux profile.

**14419.** Kunasz, P. B., Hummer, D. G., **Radiative transfer in spherically symmetric systems-III. Fundamentals of line formation**, *Mon. Notic. Roy. Astron. Soc.* **166**, No. 1, 19-55 (1974).

Key words: radiative energy loss; radiative transfer; spectral line profiles; spherically symmetric gas clouds; stellar atmospheres.

A generalization of the variable Eddington factor method is presented that makes possible the solution of line formation problems in extended spherical atmospheres whose constitutive properties depend on radius in an arbitrary way. Extensive numerical results for Doppler broadening in models with power law opacities ( $n=0,2,3$ ) are presented and interpreted. Very substantial deviations are found from the solutions of analogous plane-parallel models. The single-flight escape probability is derived for a general opacity law and is shown to exceed that for an analogous plane-parallel slab by no more than a factor of approximately two for Doppler broadening, or three-halves for Lorentz broadening. However, it is shown that each time a photon is scattered, it has a probability greater than one-half of ending its flight at a radius larger than that at which it was emitted. This effect is peculiar to spherical geometries and may be important in aiding the escape of photons from optically thick systems. Finally the effects of dilution are considered and some properties of the infinite radius, finite optical depth models are inferred. An appendix contains the solution of the line transfer problem for a homogeneous sphere by the kernel-approximation method.

**14420.** Lloyd, A. C., **A critical review of kinetics of the dissociation-recombination reactions of fluorine and chlorine**, *Int. J. Chem. Kinet.* **III**, 39-68 (1971).

Key words: bimolecular; chlorine; dissociation; evaluation; fluorine; gas; recombination; review; termolecular; third body.

A critical evaluation of the rates of the dissociation and recombination reactions of fluorine and chlorine is given. Data are presented graphically and in tabular form. The effect of various third bodies is discussed. Rate expressions for specified temperature ranges are recommended, while comparison with theoretical values obtained from the Benson and Fueno theory is made where applicable.

**14421.** Frommer, M. A., Lancet, D., **Freezing and nonfreezing water in cellulose acetate membranes**, *J. Appl. Polym. Sci.* **16**, 1295-1303 (1972).

Key words: bound water; cellulose-acetate membranes; differential scanning calorimetry; freezing of water; membranes; nuclear magnetic resonance; reverse osmosis membranes; water in membranes.

The relative amounts of freezing and nonfreezing water in various cellulose acetate (CA) membranes were determined by differential scanning calorimetry. It was found that: (1) A significant fraction (17-40%) of the water (1.0-3.1 g H<sub>2</sub>O per gram dry CA) in any membrane does not freeze at temperatures as low as -60 °C. (2) The amount of nonfreezing bound water (0.4-0.7 g nonfreezing water per gram dry CA) depends upon the nature of the membrane and is significantly higher than the total amount of water (all of which is nonfreezing) absorbed from liquid water by a dense film of the same polymer (~0.18 g water per gram dry CA). The structures of the membranes were studied by scanning electron microscopy. The results suggest that the amounts of nonfreezing water in cellulose acetate membranes decrease with the increase in the packing density (compactness) of the polymer within the membrane. In dense films, the extent of polymer-polymer interactions within the polymeric matrix is high, and therefore the macro-molecular chains are less accessible to bind water.

**14422.** Maryott, A. A., Farrar, T. C., Malmberg, M. S., **<sup>35</sup>Cl and <sup>19</sup>F NMR spin-lattice relaxation time measurements and rotational diffusion in liquid ClO<sub>3</sub>F**, *J. Chem. Phys.* **54**, No. 1, 64-71 (Jan. 1, 1971).

Key words: angular-momentum; correlation-times; molecular-reorientation; NMR-relaxation-times; <sup>19</sup>F; <sup>35</sup>Cl.

The NMR spin-lattice relaxation times of <sup>35</sup>Cl and <sup>19</sup>F have been measured by pulse techniques over the entire liquid range of ClO<sub>3</sub>F (130-368 K). The chlorine relaxation which is due solely to the nuclear quadrupole interaction can be used together with the known quadrupole coupling constant to determine the correlation time for molecular orientation,  $\tau_{\theta,2}$ . The fluorine relaxation is dominated by the spin-rotation interaction with only a small intermolecular dipole contribution at the lowest temperatures. In order to obtain the angular momentum correlation time,  $\tau_J$ , an independent estimate of the spin-rotation tensor was made by combining gas-phase measurements of  $T_1(^{19}\text{F})$  with previous data on the chemical shift and gas-phase dielectric relaxation. The results for this quasispherical molecule are in accord with rotational diffusion theory and Hubbard's relation,  $\tau_{\theta,2}\tau_J = I/6kT$ , at the lowest temperatures and agree over the entire range with the extended treatment of McClung.

**14423.** Mackay, D. R., **NBS information services on engineering standards**, *Stand. Eng.*, pp. 17-19 (June 1971).

Key words: information services; standards.

This paper covers the history of the information services provided by the National Bureau of Standards on published standards and standardization activities and describes the current ac-



tivities of the Information Section of the Bureau's Office of Engineering Standards Services.

- 14424.** Marlowe, D. E., Sushinsky, G. F., Dexter, H. B., **Elastic torsional buckling of thin-walled composite cylinders**, *Amer. Soc. Test. Mater. Spec. Tech. Publ.* **546**, pp. 84-108 (1974).

Key words: composite materials; elastic buckling; reinforced aluminum; stability; thin shells; torsional buckling.

The elastic torsional buckling strength has been determined experimentally for thin-walled cylinders fabricated with glass/epoxy, boron/epoxy, and graphite/epoxy composite materials and composite-reinforced aluminum and titanium. Cylinders have been tested with several unidirectional-ply orientations and several cross-ply layups. Specimens were designed with diameter-to-thickness ( $D/t$ ) ratios of approximately 150 and 300 and in two lengths ( $L$ ), 10 in. (25.4 cm) and 20 in. (50.8 cm).

The results of these tests were compared with the buckling strengths predicted by the torsional buckling analysis of Chao. In this analysis, the instability loads of heterogeneous anisotropic cylinders are calculated with Timoshenko's equilibrium equations. The computer program associated with the analysis seeks the solution with the lowest buckling strength by iterating on the number of circumferential buckling waves. For the cylinders considered ( $L/r=3.3$  and  $L/r=6.7$ ), the experimental buckling torques were approximately 85 percent of the torques predicted by the Chao analysis. In the cross-ply laminate cylinders, the stacking sequence of the plies was found to have a marked effect on the elastic buckling torque.

Reversal of the stacking sequence of the cross-ply cylinders resulted in buckling torques which differed by a factor of 2. Similar results were obtained by reversal of the direction of twist on the original stacking sequence. This observation may be important in applications where reversal of loading can occur. The size effect of linear scaling was investigated for cylinders whose dimensions were different but whose  $L/r$  and  $D/t$  ratios were the same. As expected from the analysis, the experimental buckling stress remained constant.

- 14425.** Meinke, W. W., **The ultimate contribution of nuclear activation to analysis**, *J. Radioanal. Chem.* **15**, 419-433 (1973).

Key words: accuracy limits; activation analysis; activation spectrometry; analytical chemistry; measurement biases; ppb; ppm; real samples; Standard Reference Materials; trace element analysis.

This paper challenges the implied accuracy of many of the analytical results below the ppm level reported in the literature. The present status of trace element techniques including activation analysis is evaluated. Practical experiences at NBS in the use of clean facilities, ultrapure reagents and special clean containers for obtaining trace composition values with known accuracy for the certification of Standard Reference Materials are described. The use of recently certified NBS Standard Reference Materials to aid the trace analyst in the biological and geochemical areas in understanding the biases of their methods is also described.

Activation spectrometry (i.e., nondestructive analysis) as opposed to activation analysis involving radiochemical separations, has the limitations of other spectrometries. However, nuclear activation analysis with careful attention to the principles of accurate measurement should be able to lower the limits of meaningful measurement of many inorganic elements several orders of magnitude during the next decade.

- 14426.** Melmed, A. J., Carroll, J. J., **Oxidation of (011) iron at room temperature: Mainly LEED aspects**, *J. Vac. Sci. Technol.* **10**, No. 1, 164-169 (Jan.-Feb. 1973).

Key words: ellipsometry; low energy electron diffraction;

metal oxidation; oxidation kinetics; oxide structure; surface potential.

The interaction of oxygen with (011) Fe at room temperature has been investigated using simultaneous combinations of LEED, ellipsometry, and surface potential measurements. This paper is concerned mainly with the LEED aspects. The sequence of LEED patterns found was either similar to that previously found or slightly different, depending on experimental conditions. In most experiments a new LEED pattern,  $p(2 \times 1)$ , was observed instead of the  $c(3 \times 1)$  pattern previously reported. Direct keying of the LEED patterns to the ellipsometry-derived growth kinetics leads to further understanding of the oxidation mechanism. The occurrence of heterogeneous oxide nucleation is supported, and it is shown that an oxide consistent with the expected diffraction properties of FeO grows to a "limiting" thickness of about 25-30 Å in oxygen. The terminal oxide in the air is concluded to have about the same thickness but a significantly different structure.

- 14427.** Crandall, D. H., Taylor, P. O., Dunn, G. H., **Electron-impact excitation of the Ba<sup>+</sup> ion**, *Phys. Rev. A* **10**, No. 1, 141-157 (July 1974).

Key words: absolute cross sections; Ba<sup>+</sup> ion; cross beams; electron impact; excitation; polarization.

Crossed beams of Ba<sup>+</sup> and electrons were used to measure the absolute emission cross sections for the Ba<sup>+</sup> lines, 455.4, 493.4, 490.0, and 413.1 + 416.6 nm. Polarization fractions of the light were also measured. The data were analyzed to extract level excitation cross sections. The excitation cross section for the  $6^2P_{3/2}$  level has a value  $34.7 \times 10^{-16}$  cm<sup>2</sup> at the 2.72-eV threshold, shows marked structure in the 3–10-eV interval, and decreases to  $1.71 \times 10^{-16}$  cm<sup>2</sup> at 747 eV. The polarization fraction for the 455.4-nm light exhibits pronounced oscillatory structure in the interval 3–7 eV. Excitation cross section for the  $6^2P_{1/2}$ ,  $7^2S_{1/2}$ , and  $6^2D_{3/2+5/2}$  levels have values at threshold of  $20.0 \times 10^{-16}$ ,  $5.4 \times 10^{-16}$ , and  $4.3 \times 10^{-16}$  cm<sup>2</sup>, respectively. Total uncertainties at a "high-confidence level" are about  $\pm 10$  percent for the  $6^2P_{1/2}$  and  $6^2P_{3/2}$  cross sections. Uncertainties range around  $\pm 30$  percent for the  $7^2S_{1/2}$  cross section and  $\pm 20$  percent for the  $6^2D_{3/2+5/2}$ . Measurements for the  $6^2P$  cross sections agree at high energies with the Coulomb distorted-wave calculation of Sheorey and Burgess. Measurements for the  $6^2P_{3/2}$  level are in quite good agreement with the measurements of Bacon and Hooper and of Pace and Hooper for energies 6 to 100 eV. However, the Pace and Hooper points at 3 and 4 eV are nearly twice the present values. Signals due to excitation of metastable  $5^2D$  ions in the ion beam were observed, and estimates could be made of the cross section for excitation from this state to the final states above. Cross sections at threshold were estimated to be  $13.4 \times 10^{-16}$  cm<sup>2</sup>  $\pm 34$  percent,  $9.8 \times 10^{-16}$  cm<sup>2</sup>  $\pm 28$  percent,  $7.4 \times 10^{-16}$  cm<sup>2</sup>  $\pm 100$  percent,  $6.9 \times 10^{-16}$  cm<sup>2</sup>  $\pm 27$  percent for excitation from the  $5^2D$  levels to the  $6^2P_{3/2}$ ,  $6^2P_{1/2}$ ,  $7^2S_{1/2}$ , and  $6^2D_{5/2+3/2}$  levels, respectively. The rate coefficients for excitation of  $6^2P_{3/2}$  calculated from the data are in reasonable agreement with the measurements of Hinnov *et al.*

- 14428.** Mebs, R. W., Carter, G. C., Evans, B. J., Bennett, L. H., **NMR chemical shifts in cuprous salts: The magnetic moment of Cu**, *Solid State Commun.* **10**, No. 9, 769-774 (1972).

Key words: chemical shifts; copper (I) compounds; copper salts; Knight shift; magnetic moment; nuclear magnetic resonance.

An extensive study has been made of chemical shifts of the <sup>63</sup>Cu resonance in a number of cuprous salts. The observed trend in chemical shifts for the cuprous halides is in disagreement with theoretical ionicity estimates of either Pauling or Phillips. This trend has been explained by taking into account the relative importance of  $\pi$  bonding for the different halides. On the basis of



the present data, CuBr is the most suitable Knight shift reference compound. The measurements indicate  $\mu = 2.2206$  nm for  $^{63}\text{Cu}$  and  $\mu = 2.3791$  nm for  $^{63}\text{Cu}$  for reference moment, without diamagnetic correction.

- 14429.** Danos, M., Rafelski, J., **Gauge invariance of the vacuum polarization in quantum electrodynamics**, *Lett. Nuovo Cimento Series 2*, **10**, No. 3, 106-110 (May 18, 1974).

Key words: gauge invariance; quantum electrodynamics; renormalization; time-ordering operator; vacuum polarization; weak interactions.

It is shown that the conventional perturbation formalism of field theory treats incorrectly the equal time point in the chronological products of field operators. If this imprecision is rectified the contradictions between the results of the perturbation expansion of the  $S$ -matrix and of the predictions of axiomatic field theory disappear. In particular, the gauge invariance violating quadratic divergence of the vacuum polarization loop does not arise in the  $S$ -matrix formulation. This is of particular importance for certain classes of the so-called nonrenormalizable field theories, e.g., the Fermi-type theories of the weak interactions.

- 14430.** Mount, G. H., Linsky, J. L., **One- and multicomponent models of the upper photosphere based on molecular spectra. II: CN(1,1) of the CN violet system**, *Solar Phys.* **35**, 259-276 (1974).

Key words: best-fit model; carbon abundance; molecular spectra; upper photosphere.

We have obtained center-to-limb photoelectric spectra of the CN(1,1) B-X bandhead region  $\lambda 3868$ - $3872$  Å at Kitt Peak National Observatory. From these spectra and a detailed analysis of the formation of the CN(1,1) spectrum we derive a best-fit upper photospheric model differing from the HSRA which is consistent with our previous CN(0,0)  $\lambda 3883$  spectra. We derive a solar carbon abundance of  $\log A_c = 8.30 \pm 0.10$  compared to the HSRA value of  $\log A_c = 8.55 \pm 0.10$ . In addition we specify the regions of formation for the CN(0,0)  $\lambda 3883.35$  and CN(1,1)  $\lambda 3871.38$  bandheads at disc center and limb.

- 14431.** Decker, G. E., Stiehler, R. D., **Standardization of Mooney viscometer and oscillating-disk cure meter**, *Amer. Soc. Test. Mater. ASTM Spec. Tech. Publ.* **553**, pp. 19-30 (1974).

Key words: cure meter; Mooney viscometer; oscillating-disk cure meter; processability; rubber testing; standardization; vulcanization.

The Mooney viscometer has been the principal instrument used to control the processability of synthetic rubber production for the past 30 years. The oscillating-disk cure meter is now becoming the principal instrument for determining the vulcanization characteristics of standard compounds of raw rubbers and compounding materials and of factory compounds used for rubber products. Therefore, a large amount of effort has been expended in their standardization. Nevertheless, both instruments which have certain similarities are affected by the following factors that still cause variability among instruments: 1. temperature of the rubber in the die cavity; 2. friction between the oscillating or rotating stem and the stationary lower die; 3. slippage at the rubber-metal interfaces; 4. the pressure on the rubber during test; and 5. scale calibration. This paper summarizes past and recent studies on these factors and indicates from recent findings the direction for further standardization.

Measurements of the disk temperature in the oscillating-disk cure meter were made. These measurements indicated that the clearance between the oscillating or rotating stem and the lower die is critical for temperature uniformity. Also, the present design of the upper die in ASTM Measurement of Curing

Characteristics with the Oscillating Disk Cure Meter (D 2084-71 T) substantially reduces the rate of heat transfer to the specimen. However, the design is reasonably effective for applying pressure on the specimen which reduces slippage at the rubber-metal interfaces. Other means of applying pressure may be used. Slippage also depends on the torque at the rubber-metal interfaces. In the Mooney viscometer, torque can be reduced by decreasing the speed of the rotor or by increasing the temperature. In the cure meter, torque is most effectively reduced by keeping the amplitude of oscillation as small as practical.

- 14432.** Mavrodineanu, R., Lazar, J. W., **Standard Reference Materials: Standard quartz cuvettes for high-accuracy spectrophotometry**, *Clin. Chem.* **19**, No. 9, 1053-1057 (1973).

Key words: cuvette, spectrophotometry; lightpath; pathlength; quartz, cuvette; radiation pathlength.

Accurate knowledge of lightpath and parallelism of cuvettes used in spectrophotometry are indispensable parameters that must be determined when accurate transmittance measurements of liquid materials are considered. A description is given of the design and techniques developed at NBS for production of quartz cuvettes (SRM 932) having a nominal radiation pathlength of  $10 \text{ mm} \pm 0.03 \text{ mm}$ . For each cuvette, pathlength and parallelism are certified with an uncertainty of  $\pm 0.0005 \text{ mm}$ . The method and instrumentation used to determine these parameters are also described.

- 14433.** Tiemann, E., Hoeft, J., Lovas, F. J., Johnson, D. R., **Spectroscopic studies of the  $\text{SO}_2$  discharge system. I. The microwave spectrum and structure of  $\text{S}_2\text{O}$** , *J. Chem. Phys.* **60**, No. 12, 5000-5004 (June 15, 1974).

Key words: centrifugal distortion; chemistry; disulfur monoxide; microwave spectra; structure; vibrational state.

The microwave spectrum of  $\text{S}_2\text{O}$  has been reexamined in order to obtain reliable predictions of all rotational transitions up to  $J = 50$  in the frequency region 10-130 GHz and to determine the structure of the molecule. A centrifugal distortion analysis has been carried out on the ground state and lowest bending vibrational state of  $^{32}\text{S}^{32}\text{S}^{16}\text{O}$ . Centrifugal distortion corrected rotational constants have also been obtained for  $^{34}\text{S}^{32}\text{S}^{16}\text{O}$  and  $^{32}\text{S}^{34}\text{S}^{16}\text{O}$ . These observations allowed the determination of the structure:  $r_s(\text{S} - \text{S}) = 1.88248(10)$  Å,  $r(\text{S} - \text{O}) = 1.4637(5)$  Å,  $\angle \text{SSO} = 118.26(7)^\circ$ .

- 14434.** Lovas, F. J., Tiemann, E., Johnson, D. R., **Spectroscopic studies of the  $\text{SO}_2$  discharge system. II. Microwave spectrum of the SO dimer**, *J. Chem. Phys.* **60**, No. 12, 5005-5010 (June 15, 1974).

Key words: centrifugal distortion; dipole moment; microwave spectrum; molecular structure; sulfur monoxide dimer; rotational spectrum.

Microwave spectra assignable to a dimer of SO have been detected in an electric discharge of  $\text{SO}_2$ . A centrifugal distortion analysis has been carried out on the spectra from the ground state and the lowest excited vibrational state of  $^{16}\text{O}^{32}\text{S}^{32}\text{S}^{16}\text{O}$  and the ground vibrational state of  $^{16}\text{O}^{32}\text{S}^{34}\text{S}^{16}\text{O}$ . The molecule was found to have a planar *cis* configuration with the following geometry:  $r(\text{SO}) = 1.458(2)$  Å,  $r_s(\text{SS}) = 2.0245(6)$  Å, and  $\angle \text{SSO} = 112.7(5)^\circ$ . The observed dipole moment of OSSO is  $\mu = 3.17(10)$  D.

- 14435.** Schwartz, R. B., Schrack, R. A., Heaton, H. T. II, **Total neutron cross sections of uranium-235, uranium-238, and plutonium-239 from 0.5 to 15 MeV**, *Nucl. Sci. Eng.* **54**, 322-326 (1974).

Key words: MeV neutrons; time-of-flight; total neutron cross sections;  $^{239}\text{Pu}$ ;  $^{235}\text{U}$ ;  $^{238}\text{U}$ .



The total neutron cross sections of  $^{235}\text{U}$ ,  $^{238}\text{U}$ , and  $^{239}\text{Pu}$  were measured over the energy range 0.5 to 15 MeV, using the U.S. National Bureau of Standards electron linear accelerator as a pulsed neutron source. Neutron energies were measured by the time-of-flight method, with a resolution of 0.1 nsec/m. The measurement accuracy is estimated to be  $\pm 1$  percent. The cross-section curve is smooth, with no observable fine structure. The data are in excellent agreement with recent results from the Rensselaer Polytechnic Institute, and in satisfactory agreement with the ENDF/B-III data file, except at the high and low energy ends of our energy range.

- 14436.** Fathers, D. J., Jakubovics, J. P., Joy, D. C., Newbury, D. E., Yakowitz, H., **A new method of observing magnetic domains by scanning electron microscopy. II. Experimental confirmation of the theory of image contrast**, *Phys. Status Solidi A*, No. 22, 609-619 (1974).

Key words: contrast measurement; image contrast; iron-silicon alloy; magnetic domains; nickel; scanning electron microscopy.

Experiments have been carried out to test the predictions of the theory of type II magnetic contrast, which is an effect enabling magnetic domains in materials including those with cubic anisotropy to be directly observed by scanning electron microscopy, previously presented in [1]. The experiments include measurements of the contrast as a function of the voltage and angle of incidence of the incident electron beam and of the angle of rotation of the specimen about its surface normal. The results are in good agreement with the theory and confirm beyond doubt that type II contrast arises from the alteration of incident electron trajectories within the solid by the internal magnetic induction. Domain images obtained by the use of type II contrast can be interpreted on the basis of this mechanism.

- 14437.** Natrella, M. G., **Design and analysis of experiments**, Section 27 in *Quality Control Handbook, Third Edition*, J. M. Juran, F. M. Gryna, Jr., and R. S. Bingham, Jr., Eds., pp. 27-1 - 27-49 (McGraw Hill Book Co., New York, N.Y., 1974).

Key words: analysis of variance; block designs; design of experiments; factorial designs; interlaboratory tests; mixture designs.

This chapter provides an introduction to the design and analysis of experiments, including a classification of designs and a summary of important recent developments. Detailed designs and methods of analysis are given for factorial and fractional factorial designs, for completely randomized designs, and for the more common types of block designs (e.g., randomized blocks, balanced incomplete blocks, Latin Squares). Descriptions are given of some special-purpose designs, such as mixture designs, group screening designs and cross-over designs. Some simple techniques that are useful in planning and analyzing the results of interlaboratory tests are included.

- 14438.** Marsden, C. P., **The formation and growth of Committee F-1**, *ASTM Stand. News* 1, No. 4, 24-28 and 54 (Apr. 1973).

Key words: ASTM; history; semiconductors; vacuum tubes.

The organization of Committee F-1, an outgrowth of Committee B-4, was formalized on June 27, 1955. Since that time, the committee has tripled its membership and increased the number of documents under its jurisdiction by a factor of six to a total of 122 documents. While retaining the original number of ten subcommittees, it has reorganized these subcommittees away from the vacuum tube industry towards the semiconductor technology. It has assumed projects on lasers and memory cores and plans to assume other aspects of the electronic technology.

- 14439.** Madey, T. E., **Chemisorption of  $\text{H}_2$  on W(100): Absolute sticking probability, coverage, and electron stimulated desorption**, *Surface Sci.* 36, 281-294 (1973).

Key words: deuterium; electron stimulated desorption; hydrogen; isotope effect; probability; tungsten.

Measurements of both the absolute sticking probability near normal incidence and the coverage of  $\text{H}_2$  adsorbed on W(100) at  $\sim 300$  K have been made using a precision gas dosing system; a known fraction of the molecules entering the vacuum chamber struck the sample crystal before reaching a mass spectrometer detector. The initial sticking probability  $\mathcal{S}_0$  for  $\text{H}_2/\text{W}(100)$  is  $0.51 \pm 0.03$ ; the hydrogen coverage extrapolated to  $\mathcal{S}_0 = 0$  is  $2.0 \times 10^{15}$  atoms  $\text{cm}^{-2}$ . The initial sticking probability  $\mathcal{S}_0$  for  $\text{D}_2/\text{W}(100)$  is  $0.57 \pm 0.03$ ; the isotope effect for sticking probability is smaller than previously reported. Electron stimulated desorption (ESD) studies reveal that the low coverage  $\beta_2$  hydrogen state on W(100) yields  $\text{H}^+$  ions upon bombardment by 100 eV electrons; the ion desorption cross section is  $\sim 1.8 \times 10^{-23}$   $\text{cm}^2$ . The  $\text{H}^+$  ion cross section at saturation hydrogen coverage when the  $\beta_1$  state is fully populated is  $\leq 10^{-25}$   $\text{cm}^2$ . An isotope effect in electron stimulated desorption of  $\text{H}^+$  and  $\text{D}^+$  has been found. The  $\text{H}^+$  ion yield is  $\geq 100 \times$  greater than the  $\text{D}^+$  ion yield, in agreement with theory.

- 14440.** Jacox, M. E., Milligan, D. E., Guillory, W. A., Smith, J. J., **Matrix-isolation study of the vacuum-ultraviolet photolysis of  $\text{NF}_3$ . The electronic spectrum of the  $\text{NF}_2$  free radical**, *J. Mol. Spectrosc.* 52, 322-327 (1974).

Key words: infrared spectrum; matrix isolation;  $\text{NF}$ ;  $\text{NF}_2$ ;  $\text{NF}_3$ ; ultraviolet spectrum; vacuum ultraviolet photolysis.

The vacuum-ultraviolet of  $\text{NF}_3$  in an argon or a carbon monoxide matrix at 14 K leads to the production of  $\text{NF}_2$ , identified by its infrared absorption. F-atom photodetachment also leads to the appearance of FCO in the carbon monoxide matrix studies. The photodissociation of  $\text{NF}_2$  by 2537 Å radiation has been confirmed. The appearance of a band system near 2600 Å with position and band spacings close to those previously reported for  $\text{NF}_2$  in the gas phase demonstrates that the lower state of the gas-phase transition is the ground state of the molecule and confirms the assignment of the observed structure to a progression in the upper-state bending vibration.

- 14441.** Pruitt, J. S., **Electron beam current monitoring system**, *Nucl. Instrum. Methods* 92, 285-297 (1971).

Key words: electron beam; errors; Faraday cup; ferrite; linac; monitor.

A beam current monitoring system used with the NBS electron linac is described in detail. The system consists of a water-cooled Faraday cup designed to dissipate the energy in a 1 cm diameter, 100 kW beam of 100 MeV electrons, and a non-intercepting ferrite loaded toroidal coil. The ferrite is used for continuous-duty monitoring and can be calibrated in absolute units with the Faraday cup. The Faraday cup errors have been measured with an absolute accuracy of better than 0.1 percent by bucking the Faraday cup current against the beam current, using the ferrite monitor as a null detector. The Faraday cup losses are about 0.5 percent at 30 MeV and decrease to less than 0.1 percent at 120 MeV. These losses are attributed to backscatter of high energy electrons from the front face of the cup. In addition, it is shown that secondary electrons produced by Møller scattering in the Faraday cup entrance foils may lead to spurious measurements of beam current, and a correction for this effect is derived.

- 14442.** Pruitt, J. S., **Correction to electron beam monitor papers**, *Nucl. Instrum. Methods* 109, 393-395 (1973).

Key words: beam; calibration electron; Faraday-cup; ferrite; monitor.



Two mistakes have been found in previously published papers about the electron beam monitor system of the NBS Linac. They invalidate the previously proposed explanation of the change in the measured Faraday cup error when vacuum foils are introduced into the beam line. When these mistakes are corrected, it is found that the generation of secondary electron by Møller scatter in the vacuum foils accounts for only about one third of the observed change, rather than all of it, as originally claimed. Additional experiments at 50 MeV have shown that the observed change is a non-linear function of foil thickness, and that the beam transmitted by the foils includes electrons with energies as small as 0.3 MeV. Electrons with this low an energy could not have been generated by Møller scattering and must be the product of multiple processes in the foils.

**14443.** Madey, T. E., **Adsorption of oxygen on W(100): Adsorption kinetics and electron stimulated desorption**, *Surface Sci.* **33**, 355-376 (1972).

Key words: adsorption; chemisorption; desorption; electron reflection; electron stimulated desorption; oxygen; single crystal W(100); surface; tungsten; work function.

The interaction of O<sub>2</sub> with a single crystal W(100) surface at ~ 300 K has been examined using a combination of techniques. A precision gas dosing system was used to deposit O<sub>2</sub> onto the crystal; the absolute accuracy in the average flux  $F$  (molecules cm<sup>-2</sup> s<sup>-1</sup>) is  $\pm 6$  percent. The initial sticking probability for O<sub>2</sub> on W(100) is effectively unity;  $S_0 = 0.98 \pm 0.03$ . The accuracy of this measurement arises from the fact that a known large fraction of the O<sub>2</sub> molecules entering the experimental chamber strike the crystal before reaching the mass spectrometer detector. The Electron Stimulated Desorption (ESD) measurements of absolute O<sup>+</sup> ion yields and energy distributions as a function of oxygen exposure were made during bombardment by 100 eV electrons. A measurable ion yield is detectable at the earliest stages of adsorption; a slight maximum in the ion yield of  $\sim 5 \times 10^{-9}$  ions/electron occurs at about one half monolayer coverage. Evidence of reconstruction of the substrate at this coverage follows from this and other work. At oxygen coverages  $\geq 4 \times 10^{14}$  molecules cm<sup>-2</sup>, a high-ion yield ESD state appears ( $\sim 10^{-6}$  O<sup>+</sup> ions/electron). An estimate of the angular distribution of ESD-liberated O<sup>+</sup> ions was made using a primitive two-segment collector. The ion angular distribution is strongly peaked in the direction normal to the surface. The functional form of this distribution is not known, but if the distribution were of the form  $\cos^n \theta$ , the results are consistent with  $n \geq 14$ . Implications of this observation for the possible identification of chemisorption sites are discussed. Work function changes and elastic electron reflection characteristics have been measured for the oxygen-covered and clean W(100) surface.

**14444.** Mopsik, F. I., **Dielectric constant and loss**, Chapter 3 in *Digest of Literature on Dielectrics* **32**, 76-99 (National Academy of Sciences, Washington, D.C. 1970).

Key words: dielectric constant; dielectric literature; dielectric loss; dielectric theory; digest of literature; ionic processes.

The coverage of this chapter is a direct continuation of last year's chapter. The papers included are those abstracted during 1968 by *Chemical Abstracts* and *Physics Abstracts* and are those that are concerned with dielectric theory, either theoretical or experimental. No attempt has been made to include papers that would adequately be covered by the preceding chapter.

**14445.** Hebner, R. E., Jr., Cassidy, E. C., Zahn, M., Sojka, R., **Electric field distributions and space charge behavior in nitrobenzene under low frequency alternating voltage**, (Proc. 1973 Annual Conference on Electrical Insulation and Dielectric Phenomena, Varennes, Quebec, Canada, Oct. 29-31, 1973), Paper in *1973 Annual Conference on Electrical Insula-*

*tion and Dielectric Phenomena*, pp. 112-119 (National Academy of Sciences, Washington, D.C., 1974).

Key words: dielectric liquids; electric field mapping; high voltage measurements; Kerr effect; nitrobenzene; space charge.

The measurement of electric field distributions in dielectric liquids during high voltage operation is of interest for applications ranging from high voltage measurements to the physics and chemistry of dielectric fluids to the prediction and control of electrical breakdown in high-voltage apparatus. For this reason, we have used the electro-optic Kerr effect to measure the spatial and temporal variations of electric fields in a nitrobenzene-filled parallel-plate capacitor. Results obtained during operation under low frequency alternating high voltages are emphasized because of the significance of studies in this frequency range for design and testing of high-voltage apparatus. The effects of voltage level and frequency on space charge density and distribution are investigated for voltage up to 20 kV rms and over a frequency range of 0-120 Hz.

The results obtained are compared both with pulses and direct voltage observations in the same system and with some recent discussions of the role of particulate charge carriers in the behavior of insulating liquids.

**14446.** Crandall, D. H., Kauppila, W. E., Phaneuf, R. A., Taylor, P. O., Dunn, G. H., **Absolute cross sections for electron-impact excitation of N<sub>2</sub><sup>+</sup>**, *Phys. Rev. A* **9**, No. 6, 2545-2551 (June 1974).

Key words: crossed beams; cross sections; excitation of N<sub>2</sub><sup>+</sup>; 1st negative band.

Crossed beams of N<sub>2</sub><sup>+</sup> and electrons were used to measure the absolute cross sections for the excitation, N<sub>2</sub><sup>+</sup>(X <sup>2</sup>Σ<sub>g</sub><sup>+</sup>,  $\nu=0$ ) +  $e \rightarrow$  N<sub>2</sub><sup>+</sup>(B <sup>2</sup>Σ<sub>u</sub><sup>+</sup>,  $\nu=0$ ) +  $e$ , over an electron energy range from below threshold (3.17 eV) to 91 eV. Absolute emissions of the 391.4-nm band were measured from impact of electrons on N<sub>2</sub><sup>+</sup> ions in various state mixtures. Corrections were made to the data to account for state mixtures and other effects to obtain the cross section for the above process. The cross section falls from its finite threshold value of  $3.0 \times 10^{-16}$  to  $0.30 \times 10^{-16}$  cm<sup>2</sup> at 91 eV. The present values are more than an order of magnitude smaller than either the 1968 values of Lee and Carleton or the 1973 values of Daschenko *et al.* At threshold the Gaunt-factor formula of Seaton predicts a value only 45 percent of that measured, but at the highest energy, the predictions of the Seaton formula have converged to within 20 percent of the present values of the cross section. Rate coefficients calculated from the present measurements are consistent with the recent rate-coefficient measurements of McLean *et al.* Total uncertainty at high confidence is about 18 percent, taken as a quadrature sum of random uncertainty (15% at 98% confidence level) with systematic uncertainties (about 8% at high confidence). The analysis leading to interpretation of the emission cross section in terms of an excitation cross section between specific states is subject to uncertainties which are not well defined, and are not included in the stated uncertainty.

**14447.** Morrissey, B. W., Stromberg, R. R., **The conformation of adsorbed blood proteins by infrared bound fraction measurements**, *J. Colloid Interface Sci.* **46**, No. 1, 152-164 (Jan. 1974).

Key words: blood proteins; infrared bound fraction; protein adsorption; protein conformation.

The likelihood that surface-induced blood coagulation results from specific protein-material interactions has led to a study of the conformation of adsorbed blood proteins. Infrared difference spectroscopy was used to determine the bound fraction, i.e., the fraction of carbonyl groups of an adsorbed molecule directly interacting with the surface, of serum albumin, prothrombin, and



fibrinogen *in situ*. Measurements were carried out on individual proteins as a function of the amount adsorbed, time of adsorption, pD, and ionic strength using a silica surface.

The results obtained for serum albumin and prothrombin indicate that the internal bonding of these globular proteins is sufficient to prevent changes in the structure while adsorbed, even at low surface population. The bound fraction of fibrinogen increases with increasing adsorbance, suggesting possible interfacial aggregation. The conformation of all three proteins was found to be independent of the time of adsorption, although major differences in the rates of adsorption were observed.

Studies of cross-linked and denatured serum albumin have provided information on the conformational changes concomitant with adsorption of the native protein. Qualitatively, such changes, if they occur, are small. This conclusion is supported by computer simulation studies of lysozyme adsorption. Studies of the effect of pD and ionic strength on the adsorbance and bound fraction of serum albumin show that caution must be exercised when identifying the plateau adsorbance of a protein isotherm with a close-packed monolayer.

**14448.** Marshall, R. D., **Surface pressure fluctuations near an axisymmetric stagnation point**, *Fluid Dyn. Trans.* **5**, Part II, 135-163 (1970).

Key words: disk; pressure fluctuations; turbulence.

Surface pressure fluctuations on a circular disk placed normal to a turbulent air stream have been investigated. Turbulence intensities of approximately 10 percent were produced by a coarse grid installed at the test-section entrance. The turbulent field in the neighborhood of the disk was homogeneous and nearly isotropic.

Experimental results indicate that existing linear theories which do not consider distortion of the flow fail to predict the nature of surface pressure fluctuations on a bluff body. Only for wavelengths which are large compared to the body do these theories yield satisfactory results. A strong attenuation of the high frequency components occurs as the flow stagnates. This is accompanied by a transfer of energy from short to long wavelengths. The opposite effect is observed as the flow attains a radial direction and approaches the edge of the disk. A neutral wavelength which undergoes little change in energy was observed. Integral scales of pressure fluctuations are much larger than the lateral integral scale of the free-stream turbulence.

Pressure-velocity correlations indicate the existence of two distinct regions, an inner region in which correlations and optimum delay times exhibit considerable change along the radius of the disk, and an outer region where there is little dependence on radial distance. Maximum values of the optimum correlations are found in the outer region. There is qualitative agreement between the experimental results and theoretical predictions which consider the effect of vortex stretching.

**14449.** Corliss, E. L. R., **Measurement of meter ballistics**, *J. Acoust. Soc. Amer.* **55**, No. 4, 889 (Apr. 1974).

Key words: impact sounds; meter ballistics; sound-level meters.

Measurements of transient phenomena such as impact sounds are influenced by the characteristics of the metering system used. This note describes a method for obtaining the undamped natural frequency and the relative damping of a meter. From this information and the measured electrical impedance of the meter circuit the ballistic behavior of the meter can be predicted.

**14450.** Newbury, D. E., Yakowitz, H., **Magnetic domain studies in iron-3 1/4 weight percent silicon transformer sheet using the scanning electron microscope**, (Proc. 18th AIP Conf. on Magnetism and Magnetic Materials, (19th Annual Conf.), Boston,

Mass., Nov. 13-16, 1973), Paper in *Magnetism and Magnetic Materials*, C. D. Graham, Jr., and J. J. Rhyne, Eds., pp. 1372-1376 (American Institute of Physics, New York, N.Y., 1974).

Key words: iron-silicon transformer alloy; magnetic contrast; magnetic domains; scanning electron microscope.

The form of the magnetic domain configuration of oriented transformer sheet plays an important role in determining the magnitude of power losses during use of the sheet. In the present work, a recently developed technique for observation of magnetic domains in iron in the scanning electron microscope (SEM) has been employed. The mechanism by which this magnetic contrast arises, and the electron-optical and signal processing requirements to obtain the contrast are described. The maximum value of the contrast is about 0.3 percent with an accelerating potential of 30kV. Changes in the domain configuration due to residual strain gradients, inclusions, and applied magnetic fields have been studied in the SEM using this contrast.

**14451.** Swartzendruber, L. J., Siegel, E., **The effect of cobalt on the formation of a non-magnetic surface developed in grinding carbon steel**, (Proc. 18th AIP Conf. on Magnetism and Magnetic Materials, (19th Annual Conf.), Boston, Mass., Nov. 13-16, 1973), Paper in *Magnetism and Magnetic Materials*, C. D. Graham, Jr., and J. J. Rhyne, Eds., pp. 735-739 (American Institute of Physics, New York, N.Y., 1974).

Key words: cobalt; grinding; Mössbauer effect; scattering; steel; surfaces.

The effect of grinding on the metallurgical and magnetic structure of the surface of carbon steels containing cobalt has been investigated using  $^{57}\text{Fe}$  Mössbauer scattering. Differences between the surface and the bulk are revealed by comparing scattering spectra obtained by counting 14 keV gamma rays with those obtained by counting conversion electrons. Light grinding produces a thin non-magnetic layer ( $\leq 0.05 \mu\text{m}$ ) of austenite (i.e.,  $\gamma \text{ Fe}$ ) on the surface of a carbon steel. This layer is too thin to be observed by conventional techniques, including glancing angle x-ray diffraction and 14 keV  $\gamma$ -ray of 6 keV x-ray detected Mössbauer scattering. A series of steels containing 3.6 a/o carbon and from 0 to 12 a/o cobalt were given identical heat treatments followed by identical grinding treatments. The cobalt is found to have considerable influence on the composition of the surface layer.

**14452.** Seltzer, S. M., Berger, M. J., **Bremsstrahlung in the atmosphere at satellite altitudes**, *J. Atmos. Terr. Phys.* **36**, 1283-1287 (1974).

Key words: atmosphere; auroral electrons; bremsstrahlung; energy spectra; Monte Carlo calculation; satellite altitudes.

Transport calculations have been made to determine the emission of bremsstrahlung by electrons in the atmosphere and the penetration of this radiation to high altitudes where it can be detected by satellite-borne instruments. The calculations were done assuming uniform wide-area precipitation into the atmosphere of an electron flux isotropic over the downward hemisphere. The intensity and energy spectrum of the bremsstrahlung have been obtained for the case of incident monoenergetic electron beams at energies between 20 keV and 2 MeV, for incident electron beams with exponential spectra with  $e$ -folding energies between 5 and 200 keV.

**14453.** Powell, C. J., **Attenuation lengths of low-energy electrons in solids**, *Surface Sci.* **44**, 29-46 (1974).

Key words: attenuation lengths; Auger-electron spectroscopy; inelastic cross sections; inelastic electron scattering at low energies; solids; x-ray photoelectron spectroscopy.

A compilation is presented of measured attenuation lengths of low-energy electrons in solids in the energy range (40 to 2000



eV) normally employed in x-ray photoelectron and Auger-electron spectroscopy. The techniques used to obtain electron attenuation lengths are summarized, and it is pointed out that the accuracy of measurement needs both to be defined adequately and to be improved for more meaningful intercomparisons of data and theory. An approximate expression is derived to predict attenuation lengths using either dielectric data (derived from optical or electron-energy-loss data) or average excitation energies estimated from electron binding energies for given materials at electron energies greater than about 500 eV. Good agreement is found between the predictions of this formula and some measured attenuation lengths (e.g., for Al, C, Mo, W) but further work is required to validate the formula and to extend it to lower electron energies.

- 14454.** Mopsik, F. I., **High pressure dielectric measurements and the theories for the dielectric constant of a liquid**, *Proc. Conf. Electrical Insulation and Dielectric Phenomena, Buck Hill Falls, Pa., Oct. 20-22, 1969*, pp. 64-68 (National Academy of Sciences, Washington, D.C., 1970).

Key words: density; dielectric constant; dielectric theory; dipole moment; high pressure; liquids; polarizability.

The conventional approach to the examination of the validity of the theories for the dielectric constant of the liquid state is to use dielectric measurements over a range of temperature and perhaps, also refractive index measurements. However, density is one of the most important variables in these theories and the molecular parameters involved could be mildly density dependent. Therefore a more valid approach is to combine high pressure dilatometry with dielectric measurements so that temperature and density dependencies of the dielectric constant can be separated.

Results of measurements to 2 kbar over a moderate range of temperature for several liquids will be presented and examined in order to establish the validity of dielectric theory.

- 14455.** Marshall, R. D., Hsi, G., **Techniques for measuring wind loads on full-scale buildings**, (Proc. U.S.-Japan Research Seminar on Wind Loads on Structures, Honolulu, Hawaii, Oct. 19-24, 1970), Paper in *Proc. of Seminar Wind Loads on Structures*, pp. 133-148 (University of Hawaii, Honolulu, Hawaii, 1970).

Key words: buildings; full-scale tests; instrumentation; pressure fluctuations; statistical analysis; wind loads.

Wind pressure measurements are being made on a four-story building on the National Bureau of Standards campus at Gaithersburg, Md. Field data will be used to develop new design criteria and to improve wind tunnel modeling techniques. Simultaneous wind velocity measurements from six meteorological towers make it possible to relate pressure distributions and fluctuations on the building to the undisturbed wind field.

- 14456.** Isbell, H. S., Pigman, W., **Mutarotation of sugars in solution: Part II**, *Advan. Carbohydr. Chem.* **24**, 14-65 (1969).

Key words: acid and base catalysts; catalysis of mutarotation; deuterium oxide mutarotation of; isotope effects in mutarotations; mechanism of mutarotation reaction; mutarotases; mutarotation of sugars; pseudo-acyclic intermediates in mutarotation; sugars, mutarotation of; thermodynamic data for mutarotations.

The publication is part of a comprehensive review describing and interpreting the changes which occur with reducing sugars in aqueous solutions. It treats, in depth catalysis by acids and bases, isotope effects, equilibrium states, thermodynamic properties, and reaction mechanisms. A new reaction mechanism is proposed in which the sugar ring is opened momentarily, forming a pseudo-acyclic intermediate, having a conformation resembling

that of the parent sugar. This intermediate passes through characteristic transition states to the various tautomeric modifications of the sugar.

- 14457.** Reader, J., **Position of the  $sp^6$  configuration in the neutral halogens**, *J. Opt. Soc. Amer. Letters to Editor* **64**, No. 7, 1017-1018 (July 1974).

Key words: bromine; chlorine; electronic configuration; halogen; iodine; spectra.

An extrapolation of the unperturbed position of the  $4s4p^6 2S_{1/2}$  level in the Br I isoelectronic sequence shows that this level will most likely lie above the ionization limit in neutral Br. It is concluded that the  $sp^6$  configuration cannot be identified in the neutral halogen atoms by isoelectronic extrapolation of observed level positions, thus calling into question the identification of this configuration in neutral chlorine, bromine, and iodine.

- 14458.** Pyke, T. N., Jr., **Terminal requirements for interactive bibliographic retrieval**, *Proc. Forum on Interactive Bibliographic Retrieval, Oct. 4-5, 1971*, pp. 9-12 (U.S. Atomic Energy Commission, Technical Information Center, Oak Ridge, Tenn., 1973).

Key words: bibliographic retrieval; computer terminals; remote computer systems.

General requirements placed on interactive terminals used for bibliographic retrieval are identified. These requirements include not only those for input/output and hard copy but also those resulting from constraints placed on the terminal by the attached communication line and computer system. The implications of these requirements on terminal design are then described, with emphasis on ideas for new, potentially useful terminal features.

- 14459.** Evans, B. J., Swartzendruber, L. J., **Supertransferred hyperfine fields at  $Sb^{5+}$  in insulating ferrites: Effects of local order and ion-specific properties**, (Proc. 18th AIP Conf. on Magnetism and Magnetic Materials, (19th Annual Conf.), Boston, Mass., Nov. 13-16, 1973), Paper in *Magnetism and Magnetic Materials*, C. D. Graham, Jr., and J. J. Rhyne, Eds., pp. 518-522 (American Institute of Physics, New York, N.Y., 1974).

Key words: ferrites; hyperfine fields; Mössbauer; Sb; YIG.

The supertransferred hyperfine fields at  $Sb^{5+}$  in  $LiFe_5O_8$ ,  $CoFe_2O_4$ , and YIG have been determined using  $^{121}Sb$  Mössbauer spectroscopy. In contrast to  $CoFe_2O_4$ ,  $NiFe_2O_4$ , and YIG, the small, average hyperfine field of  $\sim 100$  kOe at  $Sb^{5+}$  in  $LiFe_5O_8$  requires the existence of significant local order and indicates that the clustering of  $Li^{1+}$  about  $Sb^{5+}$  is approximately ten times as large as that expected for a random intrasite cation distribution, in agreement with the known strong influence of Sb substitution in destroying the Li:Fe ordering. The decrement in the hyperfine field at  $Sb^{5+}$  due to an A-site  $Co^{2+}$  is also found to be larger than that due to  $Ni^{2+}$ .

- 14460.** Maki, A. G., Sams, R. L., **Infrared spectrum of  $CS_2$ : "Hot" bands associated with the  $2185\text{ cm}^{-1}$  band and evidence for the  $CS_2$  laser assignment**, *J. Mol. Spectrosc.* **52**, 233-243 (1974).

Key words: absorption spectra; carbon disulfide; energy levels; infrared; lasers; molecular spectra.

The  $10^0 - 00^0$  band of  $CS_2$  has been measured with a resolution of  $0.030\text{ cm}^{-1}$ . The following "hot" bands associated with this transition were also measured and analyzed:  $11^1 - 01^0$ ,  $12^0 - 02^0$ ,  $12^1 - 02^0$ ,  $13^1 - 03^0$ ,  $20^0 - 10^0$ ,  $30^0 - 20^0$ ,  $21^1 - 11^0$ , and  $22^0 - 12^0$ . In addition, the  $10^0 - 00^0$  bands of the isotopic species  $^{13}C^{32}S_2$ ,  $^{12}C^{32}S^{33}S$ , and  $^{12}C^{32}S^{34}S$  were measured in natural abundance. With the results of these measurements it is shown that the  $0201 - 12^0$  transi-



tions do indeed coincide with the CS<sub>2</sub> laser transitions, as do the 00<sup>0</sup>1 – 10<sup>0</sup> transitions. New arguments are given favoring the latter assignment.

- 14461.** King, D. A., Madey, T. E., Yates, J. T., Jr., **Interaction of oxygen with polycrystalline tungsten. I. Sticking probabilities and desorption spectra**, *J. Chem. Phys.* **55**, No. 7, 3236-3246 (Oct. 1, 1971).

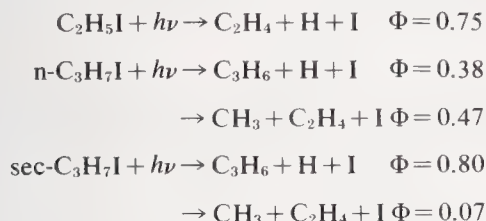
Key words: adsorption; chemisorption; flash desorption; oxidation; oxygen; tungsten; tungsten oxides.

The interaction of oxygen with a polycrystalline W filament has been studied in the temperature range 300-1200 K and for exposures between 10<sup>-7</sup> and 1 torr·sec. Both sticking probabilities and desorption spectra have been measured. After low exposures (< 2 × 10<sup>-6</sup> torr·sec) the adsorbate is all desorbed as O atoms with first order kinetics. With higher exposures, oxygen is removed as oxides: WO, WO<sub>2</sub>, WO<sub>3</sub>, W<sub>2</sub>O<sub>6</sub>. The desorption spectra for each of these species are complex, and nine distinct and reproducible oxide states are identified. Saturation coverages in each of these states are independent of adsorption temperature in the range 300-1200 K. At a total coverage of 8.5 × 10<sup>14</sup> O<sub>2</sub> molecules cm<sup>-2</sup>, 2.2 × 10<sup>14</sup> O<sub>2</sub> molecules cm<sup>-2</sup> are desorbed as oxides; after exposures > 10<sup>-2</sup> torr·sec at 300 K, the total uptake rises to 15 × 10<sup>14</sup> O<sub>2</sub> molecules cm<sup>-2</sup>. At temperatures between 500 and 1000 K and exposures up to 1 torr·sec, a multilayer oxide film is formed of unlimited thickness. The desorption product from this oxide film is predominantly WO<sub>2</sub>, which desorbs in the region of 1200 K. The kinetics of adsorption and desorption are evaluated and discussed.

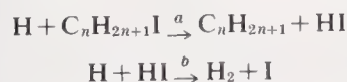
- 14462.** Rebbert, R. E., Lias, S. G., Ausloos, P., **Photolysis of alkyl iodides at 147.0 nm. The reaction H + C<sub>n</sub>H<sub>2n+1</sub>I → HI + C<sub>n</sub>H<sub>2n+1</sub>**, *Int. J. Chem. Kinet.* **V**, 893-908 (1973).

Key words: alkylhalides; far ultraviolet photochemistry; free radicals; hydrogen atoms; photochemical dissociation; rate constants.

The 147 nm (8.4 eV) photolysis of gaseous C<sub>2</sub>H<sub>5</sub>I, n-C<sub>3</sub>H<sub>7</sub>I, and sec-C<sub>3</sub>H<sub>7</sub>I was investigated in the presence of and absence of HI. The main overall processes are:



These dissociative processes occur mainly as a result of initial cleavage of the weak C – I bond, followed by decomposition of the internally excited alkyl radicals. In all cases, approximately 5-10 percent of the alkyl radicals thus formed do not undergo dissociation at pressures around 3-7 torr. There is also evidence for the elimination of HI as well as C – C cleavage in the primary dissociation. The former is indicated by deuterium labeling experiments and the formation of cyclopropane (Φ = 0.04) as a product in the photolysis of n-C<sub>3</sub>H<sub>7</sub>I. Because the processes listed above provide a constant source of H atoms whose quantum yield can be exactly determined, it was feasible to obtain accurate values for  $k_a/k_b$ :



For thermally equilibrated H atoms (300 K),  $k_a/k_b$  is 0.44 ± 0.04, 0.57 ± 0.06, 0.95 ± 0.1, and 0.024 ± 0.01 for C<sub>2</sub>H<sub>5</sub>I, n-C<sub>3</sub>H<sub>7</sub>I, sec-C<sub>3</sub>H<sub>7</sub>I, and C<sub>2</sub>H<sub>5</sub>Br, respectively.

- 14463.** Hellner, L., Sieck, L. W., **High-pressure photoionization mass spectrometry. Effect of internal energy and density on the ion-molecule reactions occurring in methyl, dimethyl, and trimethylamine**, *Int. J. Chem. Kinet.* **V**, 177-186 (1973).

Key words: amines; collisional stabilization; ionization energy effect; mass spectrometry; photoionization; rate constants.

The ion-molecule reactions of CH<sub>3</sub>NH<sub>2</sub><sup>+</sup>, (CH<sub>3</sub>)<sub>2</sub>NH<sup>+</sup>, and (CH<sub>3</sub>)<sub>3</sub>N<sup>+</sup> with the respective amines have been investigated at thermal kinetic energies in a high-pressure photoionization mass spectrometer at several wavelengths (energies) in the vacuum ultraviolet. The absolute rate coefficient for proton transfer from (CH<sub>3</sub>)<sub>3</sub>N<sup>+</sup> to (CH<sub>3</sub>)<sub>3</sub>N decreases from 8.2 × 10<sup>-10</sup> cm<sup>3</sup>/molecule·sec at 147.0 nm (8.4 eV) to 4.9 × 10<sup>-10</sup> cm<sup>3</sup>/molecule·sec at 106.7 – 104.8 nm (11.7 eV). In dimethylamine, the rate coefficient decreases from 11.6 × 10<sup>-10</sup> cm<sup>3</sup>/molecule·sec at 8.4 eV to 10.2 × 10<sup>-10</sup> cm<sup>3</sup>/molecule·sec at 11.7 eV, while no significant effect of energy was detected in methylamine. The reactions of several fragment ions are also reported. Experiments were also carried out at pressures up to 0.5 torr in order to investigate the further solvation of CH<sub>3</sub>NH<sub>2</sub><sup>+</sup>, (CH<sub>3</sub>)<sub>2</sub>NH<sub>2</sub><sup>+</sup>, and (CH<sub>3</sub>)<sub>3</sub>NH<sup>+</sup>. It was found that the maximum proton solvation numbers in methyl-, dimethyl-, and trimethylamine are 4, 3, and 2, respectively, under these conditions.

- 14464.** Sieck, L. W., Gorden, R., Jr., **Photoionization of N<sub>2</sub>O at 73.6 – 74.4 and 58.4 nm. Evidence for collision-induced dissociation at thermal kinetic energies**, *J. Chem. Phys.* **58**, No. 6, 2653-2654 (Mar. 15, 1973).

Key words: ion-molecule reaction; mass spectrometry; N<sub>2</sub>O; rate constant; vapor phase.

The photoionization of N<sub>2</sub>O at 73.6-74.4 and 58.4 nm has been investigated in the NBS high pressure mass spectrometer up to approximately 0.1 torr. Evidence has been found for the collision-induced dissociation



which occurs at thermal kinetic energies and involves excited levels with lifetimes >> 10<sup>-5</sup> s. Experiments with various additive gases have revealed that initial population of the A<sup>2</sup>Σ level (certainty), and B<sup>2</sup>π and C<sup>2</sup>Σ (possibly) results in formation of the N<sub>2</sub>O<sup>+</sup> states responsible for the dissociation. No evidence was found for participation of vibrationally excited ground state X<sup>2</sup>π states in this reaction.

- 14465.** Sieck, L. W., Gorden, R., Jr., **Formation of association ions in the photoionization of alkyl halides**, *Int. J. Chem. Kinet.* **5**, No. 3, 445-454 (May 1973).

Key words: alkyl halides; ion-molecule reactions; mass spectrometry; photoionization; radiolysis; rate constants.

The methyl and ethyl chlorides and bromides, as well as methyl iodide, were photoionized in the vacuum ultraviolet at 300 K in a mass spectrometer over the pressure range 0.5 to approximately 100 millitorr. Under these conditions, stabilized parent ion dimers are found in CH<sub>3</sub>Br, CH<sub>3</sub>I, and C<sub>2</sub>H<sub>5</sub>Br, but not in the chlorides. Lower limits for the dissociative lifetimes of the ion-molecule collision complexes were estimated and are as follows: (CH<sub>3</sub>Br)<sub>2</sub><sup>+</sup>, 1.6 μs; (CH<sub>3</sub>I)<sub>2</sub><sup>+</sup>, 1.9 μs; and (C<sub>2</sub>H<sub>5</sub>Br)<sub>2</sub><sup>+</sup>, 5.4 μs. An increase in photon energy (internal energy content of the reactant ion) decreases the dissociative lifetime of the collision complex in CH<sub>3</sub>I.

- 14466.** Little, J. L., **ASCII code applications to alphanumeric display terminals**, *Proc. Society for Information Display Terminals*, Gaithersburg, Md., Nov. 30-Dec. 1, 1971, **14**, No. 2, Second Quarter, 67-72 (1973).



Key words: alphanumeric displays; ASCII code; cathode-ray-tube displays; control functions; display terminals; interactive terminals; remote computer terminals; soft copy; text-editing displays; visual displays.

This paper reviews briefly the evolution of the American Standard Code for Information Interchange (ASCII) and its international version (ISO R-646). It also reviews the evolutionary impact of typewriters, teletypewriters and the ASCII code on conventions now employed in alphanumeric display terminals. It shows a proposed keyboard layout, some approved graphic subsets of ASCII, and some codes used in computers. Current developments in the representation of extended versions of ASCII in 7 and 8 bits are given. Proposed standards for control functions for alphanumeric display terminals are also included, with a warning that their standardization is under the jurisdiction of the American National Standards Institute's Technical Committee X3L2 on Character Codes.

**14467.** Meyerson, M. R., **International voluntary standards, Food Technol.**, pp. 58 and 62 (Nov. 1972).

Key words: consumer standards; DoC-NBS voluntary product standards; international standardization; international trade; national standards.

Various aspects of the activities of the National Bureau of Standards in national programs of voluntary consensus standards writing are discussed, and the operation of the DoC-NBS Voluntary Product Standards Program described. This is followed by observations and a discussion of the role of standardization in international trade.

**14468.** Rice, J. R., Thomson, R., **Ductile versus brittle behaviour of crystals, Phil. Mag.** **29**, No. 1, 73-97 (Jan. 1974).

Key words: dislocation nucleation; ductile vs. brittle; fracture; theoretical strength.

A necessary criterion for brittle fracture in crystals is established in terms of the spontaneous emission of dislocations from an atomically sharp cleavage crack. We have calculated the stability of a sharp crack against emission of a blunting dislocation for a number of crystals and crystal types in two dimensions and the energy to form a stable loop of dislocation from the crack tip in three dimensions. We find that contrary to previous expectations, an atomically sharp cleavage crack is stable in a wide range of crystal types, but that in the face centred cubic metals investigated, blunting reactions occur spontaneously. Of the body centred metals investigated, iron is an intermediate case between the brittle and ductile cases, and the ionic and covalent crystals investigated are all stable against dislocation emission. Qualitatively, we find that crystals whose dislocations have wide cores, and small values of the parameter  $\mu b/\gamma$  ( $\mu b/\gamma \lesssim 7.5$  to 10) are ductile while crystals with narrow cores and large values of  $\mu b/\gamma$  are brittle.

**14469.** Eyler, J. R., Ausloos, P., Lias, S. G., **A novel ion-molecule reaction involving cleavage of the carbonyl bond in ketones and aldehydes, J. Amer. Chem. Soc.** **96**, No. 11, 3673-3675 (May 29, 1974).

Key words: aldehyde-chlorocarbon ion; fluorocarbon ion; halocarbon ions; ion-cyclotron resonance; ion-molecule reaction; ketone; mass spectrometer.

The reactions of  $\text{CF}_3^+$ ,  $\text{CCl}_3^+$ , and  $\text{C}_2\text{F}_5^+$  with aldehydes and ketones have been investigated. Ninety-five percent or more of the reactive encounters between  $\text{CF}_3^+$  or  $\text{CCl}_3^+$  and  $\text{CH}_3\text{COCH}_3$ ,  $\text{CH}_3\text{CHO}$ ,  $\text{C}_2\text{H}_5\text{COCH}_3$ ,  $\text{C}_2\text{H}_5\text{COC}_2\text{H}_5$ , and  $n\text{-C}_4\text{H}_9\text{COCH}_3$  result in a reaction in which an O atom and a  $\text{F}^+$  or  $\text{Cl}^+$  are exchanged, in what is apparently a concerted mechanism:



(where X is F or Cl, R and R' are H,  $\text{CH}_3$ ,  $\text{C}_2\text{H}_5$ , or  $n\text{-C}_4\text{H}_9$  as appropriate). The product  $\text{R}'\text{CXR}^+$  ions have a tendency to dissociate by losing HX; the stability of the  $\text{R}'\text{CXR}^+$  ions vis-a-vis this dissociation is very sensitive to the exothermicity of the  $\text{CX}_3^+ + \text{R}'\text{COR}$  reaction, showing a greater tendency to dissociate for larger  $\text{R}'\text{COR}$  reactant molecules. Further, the rate constants of the reactions of  $\text{CCl}_3^+$  are slower by 1-2 orders of magnitude ( $10^{-11}$ - $10^{-10}$   $\text{cm}^3/\text{molecule-sec}$ ) than the rates of the corresponding reactions of  $\text{CF}_3^+$  ( $10^{-9}$   $\text{cm}^3/\text{molecule-sec}$ ). The  $\text{C}_2\text{F}_5^+$  ion undergoes a reaction analogous to I with these carbonyl compounds, but with ketones larger than acetone an important alternate reaction channel leads to the formation of  $\text{CF}_3\text{CO}^+$  product ions.

**14470.** Spiegel, V., **Age of californium-252 fission neutrons to indium resonance energy in water, Nucl. Sci. Eng.** **54**, 28-34 (1974).

Key words: age; fission spectrum; neutron; neutron age;  $^{252}\text{Cf}$ .

The age of  $^{252}\text{Cf}$  fission neutrons to indium resonance energy (1.44 eV) was measured in water using a source encapsulated in a 7.6-mm-diam by 7.6-mm-high cylinder. The correction for the displacement of the moderator by the source was experimentally determined to be -0.13  $\text{cm}^2$  or about -0.5 percent in approximate agreement with calculation. The distribution of indium resonance energy neutrons close to the source was measured to be Gaussian. The age measured for this experiment was  $28.69 \pm 0.39$   $\text{cm}^2$ . An average energy for the  $^{252}\text{Cf}$  neutron spectrum of  $2.21 \pm 0.05$  MeV is inferred from this age.

**14471.** Freeman, D. H., **The gels for liquid chromatography, J. Chromatogr. Sci.** **11**, 175-179 (Apr. 1973).

Key words: gel; ion exchange; liquid chromatography.

This paper attempts to unify an understanding of various chromatographic gels. First, all gels are reviewed for their common tendency to fractionate on the basis of steric exclusion. The chemical contribution to chromatographic affinity is superimposed. Descriptions of interactive effects and reactive ion exchange processes are referred to their major chemical equilibria. The use of this understanding for solving chemical separation problems is described.

**14472.** Freeman, D. H., Angeles, R. M., Enagonio, D. P., May, W., **Interactive gel networks. Chromatographic and analytical properties with a pyridine type functional group, Anal. Chem.** **45**, 768-774 (Apr. 1973).

Key words: chromatography (liquid); interactive gel; organic separations.

The gel is a copolymer of 2-methyl-5-vinyl pyridine with DVB cross-linking. The composition, infrared absorption, swelling, and gel permeation properties were measured. The pyridine moiety is basic, as indicated by its ability to complex ROH and RCOOH solutes. Chromatographic affinity is directly related to the strength of the solute:gel complex. Solvents mask the pyridine gel in the order  $\text{EtOH} > \text{CHCl}_3 > \text{CCl}_4$ . The resulting solute affinity varies oppositely with the strength of the solvent:gel complex. ROH affinity correlates systematically with the proton donor strength. Gel capacity is high and several applications are described.

**14473.** Roszman, L. J., Hooper, C. F., Jr., **Time-dependent plasma microfield distribution, Physica** **73**, 259-286 (1974).

Key words: cluster expansion; collective-coordinates; distribution; ion correlations; microfield; plasma; time-dependent microfield.

The theory of the distribution of the finite-interval time average of the time-dependent low-frequency microfield (ion



produced) in a plasma containing ion-ion correlations is developed. The plasma model contains ion-ion interactions in the appropriate statistical ensemble (statistical ion correlations), but does not contain ion interactions in its dynamics (free-streaming dynamics). The theory allows inclusion of statistical ion correlations to any order. A discussion of all approximations is included.

- 14474.** Torchia, D. A., Piez, K. A., **Mobility of elastin chains as determined by  $^{13}\text{C}$  nuclear magnetic resonance**, *J. Mol. Biol. Letters to Editor* **76**, 419-424 (1973).

Key words: carbon-13 relaxation times; collagen; configurational entropy; correlation times; elastic properties; elastin; ligamentum nuchae; rotational correlation times.

Relaxation times and integrated intensities of  $^{13}\text{C}$  have been obtained from nuclear magnetic resonance spectra of elastin in unstretched calf ligamentum nuchae and indicate that about 80 percent of the backbone carbonyl carbons have short rotational correlation times,  $\tau_R \sim 40$  nanoseconds.  $\tau_R$  is reduced by only a factor of two when the ligament is in contact with 2M-KCNS, a strong denaturant. By contrast, the highly ordered chains of collagen in insoluble calf achilles tendon give no spectrum until denatured in 2 M-KCNS, when  $\tau_R$  decreases by many orders of magnitude. These results show that elastin is composed largely of highly mobile chains under physiological conditions, suggesting that configurational entropy has an important role in its elastic properties.

- 14475.** Torchia, D. A., Lyster, J. R., Jr., **Molecular mobility of polypeptides containing proline as determined by  $^{13}\text{C}$  magnetic resonance**, *Biopolymers* **13**, 97-114 (1974).

Key words: biopolymers; carbon-13 magnetic resonance; polypeptides; relaxation times.

The molecular conformations and dynamics of poly(L-prolyl), poly(hydroxyl-L-prolyl), poly(L-prolyl-glycyl), poly(hydroxyl-L-prolyl), and poly(glycyl-glycyl-L-prolyl-glycyl), in aqueous solution, have been studied using  $^{13}\text{C}$  pulse Fourier transform nmr spectroscopy. From a measurement of the intensities of major and minor resonances in the spectra of the copolypeptides, it was determined that 15-20 percent of the glycyl-prolyl and glycyl-hydroxyprolyl peptide bonds are *cis*. Effective rotational correlation times ( $\tau_{\text{eff}}$ ), obtained from measurements of spin-lattice relaxation times ( $T_1$ ) of individual backbone and side-chain carbons, demonstrated that backbone reorientation is approximately isotropic for the five polypeptides and is characterized by correlation times of ca. 0.3-0.6 nanoseconds as a result of rapid segmental motion. In a given polypeptide glycyl and pyrrolidine residues were found to have the same backbone correlation times, but backbone carbon  $\tau_{\text{eff}}$  values did decrease as the glycyl content of the peptides increased. A semi-quantitative analysis of  $C^\beta$ ,  $C^\alpha$ , and  $C^\gamma$  correlation times suggests that rapid ring motion in both prolyl and hydroxyprolyl involves primarily  $C^\alpha$  and  $C^\beta$ , with the prolyl ring being more mobile than the hydroxyprolyl ring.

- 14476.** Thomson, R. M., **The fracture crack as an imperfection in a nearly perfect solid**, *Annu. Rev. Mater. Sci.* **3**, 31-51 (1973).

Key words: brittle material; cleavage; deformation; fracture; hydrogen embrittlement; mechanical properties; stress corrosion; ultimate strength.

The field of fracture is reviewed from the standpoint of physical models which are used and appraisal is attempted of the major areas where new theoretical physical progress is required. Topics include fracture vs. ductility, Griffith criterion, nonlinear theories, atomic theories and effects of atmospheres.

- 14477.** Simmons, J. H., **Miscibility gap in the system  $\text{PbO-B}_2\text{O}_3$** , *J. Amer. Ceram. Soc.* **56**, No. 5, 284-285 (May 1973).

Key words: glass; lead-borate; immiscibility temperatures.

The immiscibility temperatures of lead-borate glasses are reported. The data indicate the existence of a  $\text{PbO} \cdot 4\text{B}_2\text{O}_3$  structure in the melt. A fit of the data by a regular mixing equation leads to the calculation of miscibility gap and spinodal boundaries.

- 14478.** Schaefer, A. R., Mohan, K., **A new gonioradiometer for total flux measurements**, *J. Illum. Eng. Soc.* **3**, No. 4, 349-353 (July 1974).

Key words: geometrically total luminous; gonioradiometer; spectral radiant flux.

This paper describes the design, construction, and characterization of a new instrument for the measurement of geometrically total flux. This is done by measuring the flux emanating from a source in different directions and integrating it over an entire imaginary surface surrounding the source. A new approach is suggested for the realization of the scales of total luminous flux and geometrically total spectral flux. In this approach, these scales would be derived from standards of irradiance and illuminance.

- 14479.** Paffenbarger, G. C., Rupp, N. W., **Composite restorative materials in dental practice: A review**, *Int. Dent. J.* **24**, No. 1, 1-11 (Mar. 1974).

Key words: abrasion resistance; BIS-GMA; coefficient of thermal expansion; composite resin; compressive strength; silane coupling agent; silicate filler.

This review of the literature concerning composite resins discusses the composition, physical properties, uses and the manipulation techniques for some current, 1973, commercial products. These restorative materials are based upon the BIS-GMA resin reinforced with inorganic silicious fillers bonded to the resin matrix with a silane coupling agent. Their use is limited to the restoration of non-load bearing surfaces of the teeth.

- 14480.** Simmons, J. H., Mills, S. A., Napolitano, A., **Interaction of microstructure development with viscous flow processes in glass**, *J. Non-Cryst. Solids* **14**, 302-309 (Jan. 1974).

Key words: microstructure; phase separation; viscosity.

Measurements in glasses undergoing phase separation showed a large increase of viscosity with heat-treatment time. A correlation of this effect with electron micrographs of the structure indicated that the change in viscosity was related to an increase in size of the microstructure. A theoretical analysis is presented which is based on a model relating point-to-point variations in molecular environments to viscous flow processes in glass.

- 14481.** Siu, M. C. I., **Equations for thermal transpiration**, *J. Vac. Sci. Technol.* **10**, No. 2, 368-372 (Mar.-Apr. 1973).

Key words: anomalous Knudsen limit; de Broglie wavelength; diffuse scattering; distribution function; free-molecular flow; irreversible thermodynamics; specular reflection.

A formalism for analytically obtaining an expression for the thermal transpiration pressure ratio  $R$  is presented. An experimental parameter  $\sigma$ , which is associated with the type of molecule-solid surface collisions, is introduced. A completely diffuse scattering and a completely specular scattering from a solid surface correspond to  $\sigma=0$  and  $\sigma=1$ , respectively. A known distribution function is used to derive a practical formula for  $R$  in the case of long tubes and very low pressures. Quantitative results obtained from this formula indicate that deviations from completely diffuse scattering of molecules from solid surfaces give rise to an anomalous Knudsen limit.

- 14482.** Sieck, L. W., Gorden, R., Jr., Ausloos, R., Lias, S. G., Field, F., **Ion-clustering of the cations in the high energy ir-**



radiation of nitrous oxide, *Radiat. Res.* **56**, No. 3, 441-459 (Dec. 1973).

Key words: ion clustering; ion-molecule reactions; mass spectrometry; nitrous oxide; photoionization radiolysis.

The reactions of the positive ions in  $N_2O$  have been studied mass spectrometrically at pressures up to approximately 2 torr and at temperatures in the vicinity of 300 K, that is, under conditions similar to those which prevail in a gas phase radiolysis experiment.

The  $N_2O^+$  parent ion associates with a  $N_2O$  molecule to form a  $(N_2O)_2^+$  dimer, with a termolecular rate constant of  $4.8 \pm 0.5 \times 10^{-28}$  cm<sup>6</sup>/molecule<sup>2</sup>-sec at 300 K. The ratio  $(N_2O)_2^+/N_2O^+$  shows a sharp decrease with an increase in temperature. The  $NO^+$  fragment ion also associates with a  $N_2O$  molecule to form the  $NO^+ \cdot N_2O$  association ion. At pressures greater than 1 torr, this ion associates with a second molecule of  $N_2O$  to form  $NO^+ \cdot (N_2O)_2$ .

In order to investigate the effects of accumulated radiolytic products on the ionic mechanisms in  $N_2O$ , experiments were performed in which small amounts ( $\sim 0.1\%$ ) of  $O_2$ ,  $NO$ , and  $N_2$  were added to  $N_2O$ . In the presence of 0.1 percent  $O_2$ ,  $O_2^+ \cdot N_2O$  is formed. In the presence of 0.1 percent  $NO$ ,  $NO^+ \cdot N_2O$  and  $(N_2O)_2NO^+$  were observed in much greater abundance than in pure  $N_2O$ , presumably from a reaction of  $N_2O^+$  or  $(N_2O)_2^+$  with  $NO$  molecules. The  $(NO)_2^+$  dimer ion was also observed in these experiments. No reactions of the positive ions in  $N_2O$  with  $N_2$  were observed.

The results obtained in earlier pulse radiolysis and conventional low dose rate radiolysis experiments are reevaluated in order to take into account the formation of association ions. If one assumes that no dissociation occurs in the  $N_2O$  species formed by neutralization of  $(N_2O)_n^+$  ions by  $SF_6^-$ , it can be shown that observed pulse radiolysis results are consistent with the electron neutralization of  $(N_2O)_n^+$  to give only one excited  $N_2O^*$  species which dissociates; an alternate assumption about the neutralization mechanism involving  $SF_6^-$  leads to the conclusion that, on the average, 1.8  $N_2O$  species dissociate for each  $(N_2O)_n^+$  ion neutralized by an electron. In the low dose rate radiolysis, accumulated products may be expected to modify the ionic mechanism, so that radiolytic product yields will be dependent on dose.

**14483.** Sieck, L. W., Gorden, R., Jr., Ausloos, P., **Effects of low concentrations of  $O_2$  and CO on the ion-clustering reactions in the lower ionosphere of Mars**, *Planet. Space Sci. Research Notes* **21**, 2039-2041 (1973).

Key words: ion clusters; ion-molecule reactions; ionosphere; Martian atmosphere; mass spectrometry; photoionization.

It is demonstrated that under conditions which approximate those of the Martian ionosphere traces of CO and  $O_2$  can be effectively incorporated in ion clusters via ion-molecule reaction schemes initiated by the  $CO_2^+$  ion. For example, when 0.3 percent CO is added to  $CO_2$ ,  $(CO)_2^+$  and  $[(CO)_2CO_2]^+$  appear as the major cations (584 Å radiation, 300 K). In mixtures containing  $O_2$  in addition to CO,  $(CO_2 \cdot O_2)^+$  and  $[(CO_2)_2O_2]^+$  are important species. A recently proposed mechanism to account for the low abundance of CO and  $O_2$  in the Martian atmosphere is discussed in the light of these observations.

**14484.** Gadzuk, J. W., **Reply to comments on a theory of field-induced tunneling**, *Phys. Rev. B* **3**, No. 5, 1772-1773 (Mar. 1, 1971).

Key words: adsorption; field emission; surface physics; tunneling.

The implication of an observation by Glasser relevant to past theories of field emission are discussed.

**14485.** Kelley, R. D., Klein, R., **Cross disproportionation of alkyl radicals**, *J. Phys. Chem.* **78**, No. 16, 1586-1595 (1974).

Key words: alkyl radicals; cross disproportionation; steric effects.

The cross disproportionation of several alkyl radicals has been measured using a novel technique that eliminates most of the uncertainties characterizing previous gas-phase results. The radicals are prepared in the condensed phase at 90 K by the H atom addition to a mixture of two olefins. The concentrations are adjusted so that one of the two radicals produced is in great excess. The other radical, then, is involved only in cross and not in autodisproportionation. From the results of a number of measurements, it is shown that alkyl radical disproportionation is governed almost completely by steric factors whereby the hydrogen acceptor-donor characteristics of each radical of the cross-disproportionating pair are independent of the counter radical. The cross disproportionation of an alkyl radical containing a double bond shows that the double bond has an orienting effect on the approach to and reaction with a second radical.

**14486.** Swartzendruber, L. J., Bennett, L. H., **Retained austenite developed during surface grinding of a carbon steel**, *Scr. Met.* **6**, No. 8, 737-741 (1972).

Key words: electron conversion; Mössbauer; retained austenite; standard sample; steel.

Light surface grinding on a spheroidized Fe-C alloy of the eutectoid composition raises the surface layer to a temperature sufficient to dissolve the carbide particles. The rapid quenching provided by the sample substrate and the cutting fluid retains a surface layer of austenite approximately 0.01  $\mu$ m thick. Mössbauer scattering experiments, using electron conversion, can detect the retained austenite.

**14487.** Swartzendruber, L. J., **Localized moments on Fe impurities in Nb-Mo alloys: Mössbauer effect absorber study**, *Int. J. Magn.* **2**, 129-138 (1972).

Key words: alloys; iron; magnetic moments; molybdenum; Mössbauer effect; niobium.

Mössbauer effect spectra for absorbers of Mo and  $Mo_{0.8}Nb_{0.2}$  alloys containing  $^{57}Fe$  impurities have been obtained in an external field as a function of temperature. The spectra for the Mo-Fe alloys are in close agreement with the results of Kitchens *et al.* for  $(^{57}Co)Mo$  sources. The  $Mo_{0.8}Nb_{0.2}$  spectra show the presence of two distinct moment values for the Fe impurities, one with a moment of 1.9  $\mu_B$  and one with a moment of zero (with experimental upper limit of 0.6  $\mu_B$ ). The two moment species are present in nearly equal proportions. This result gives direct support for a discontinuous moment formation model of the type proposed by Jaccarino and Walker. The saturation hyperfine field of 115 kG for Fe in Mo is apparently reduced to 90 kG for moment bearing Fe in  $Mo_{0.8}Nb_{0.2}$ . There appears to be no quenching of the Fe moment for Fe-Fe pairs such as that observed for Co-Co pairs in Mo-Nb alloys.

**14488.** Lesclaux, R., Searles, S., Sieck, L. W., Ausloos, P., **Modes and rates of reaction of cyclopentene and methylcyclopentene ions with their parent molecules**, *J. Chem. Phys.* **54**, No. 8, 3411-3418 (Apr. 15, 1971).

Key words: cyclopentene; ion-molecule reactions; mass spectrometry; methyl cyclopentene; photoionization; vacuum ultraviolet.

Cyclopentene and methylcyclopentene ions were generated by irradiating the respective parent compounds with 10.0-eV photons; cyclopentene was also irradiated with 11.6–11.8-eV photons. The ionic products of ion-molecule reactions were observed in the NBS high-pressure photoionization mass spectrometer, while the neutral products of these reactions were



determined by chemical analysis of products formed in photolytic experiments in a closed system. The cyclopentene ion, which at 10.0 eV retains its cyclic structure, undergoes an  $H_2$  transfer reaction ( $c-C_5H_8^+ + c-C_6H_8 \rightarrow c-C_5H_{10} + c-C_5H_6^+$ ,  $k = 3.3 \times 10^{-10}$  cm<sup>3</sup>/molecule·sec) and a condensation reaction ( $c-C_5H_8^+ + c-C_5H_8 \rightarrow C_{10}H_{16}$ ,  $k = 2.7 \times 10^{-10}$  cm<sup>3</sup>/molecule·sec) with the parent molecule. The same reactions are observed for ions formed at 11.6–11.8 eV, but at the higher energy, approximately 20 percent of the ions are observed to undergo ring opening to form 1,3- $C_5H_8^+$  ions; the latter ions undergo an  $H_2$  transfer reaction with the cyclopentene molecule ( $1,3-C_5H_8^+ + c-C_5H_8 \rightarrow 2-C_5H_{10} + C_5H_6^+$ ,  $k = 1 \times 10^{-10}$  cm<sup>3</sup>/molecule·sec). The three methylcyclopentene ions also undergo  $H_2$  transfer reactions with the corresponding parent molecules [ $C_6H_{10}^+ + C_6H_{10} \rightarrow (CH_3)C_5H_9 + C_6H_8^+$ ,  $k = 4.6$ , 1.8, and  $2.9 \times 10^{-10}$  cm<sup>3</sup>/molecule·sec for 1-, 3-, and 4-methylcyclopentene, respectively]. Condensation reactions between these ions and their parent molecules are observed to only a minor extent, but a second major mode of reaction, namely H transfer, is observed ( $C_6H_{10}^+ + C_6H_{10} \rightarrow C_6H_{11} + C_6H_9^+$ ,  $k = 0.6$ , 2.8, and  $1.2 \times 10^{-10}$  cm<sup>3</sup>/molecule·sec for 1-, 3-, and 4-methylcyclopentene, respectively). Structural reasons for these rate variations are discussed.

**14489.** Burke, R. W., Diamondstone, B. I., Velapoldi, R. A., Menis, O., **Mechanisms of the Liebermann-Burchard and Zak color reactions for cholesterol**, *Clin. Chem.* **20**, No. 7, 794–801 (1974).

Key words: carbonium ion formation; cholestapolyenes; cholesterol; enylic cations; Liebermann-Burchard; oxidative reactions; reaction mechanisms; Zak.

Correlation of  $SO_2$  and  $Fe^{2+}$  measurements with new spectral data indicates that the Liebermann-Burchard (L-B) and Zak color reactions for cholesterol have similar oxidative mechanisms, each yielding, as oxidation products, a homologous series of conjugated cholestapolyenes. These studies further suggest that the colored species observed in these two systems are enylic carbonium ions formed by protonation of the parent polyenes. Thus, the red ( $\lambda_{max}$ , 563 nm) product typically measured in the Zak reaction is evidently a cholestatetraenylic cation, and the blue-green product in the L-B reaction ( $\lambda_{max}$ , near 620 nm) is evidently the pentaenylic cation. The effects of rate of carbonium ion formation and sulfuric acid concentration on sensitivity and color stability are discussed. A solvent extraction procedure is described for specifically converting cholesterol to 3,5-cholestadiene. Incorporating this step into the typical L-B method can increase the L-B sensitivity for cholesterol by several fold.

**14490.** Lias, S. G., Viscomi, A., Field, F. H., **Chemical ionization mass spectra. XXI. Reactions in  $t-C_5H_{11}Cl$ ,  $t-C_5H_{11}Br$ ,  $t-C_5H_{11}OH$ , and  $t-C_5H_{11}SH$** , *J. Amer. Chem. Soc.* **96**, No. 2, 359–364 (Jan. 23, 1974).

Key words: alcohols; alkyl halides; chemical ionization; ion-molecule reactions; mass spectrometry; mercaptans.

Mixtures of isobutane with small amounts (0.01–1%) of added  $t-C_5H_{11}Cl$ ,  $t-C_5H_{11}Br$ ,  $t-C_5H_{11}OH$ , and  $t-C_5H_{11}SH$  have been studied in a high-pressure mass spectrometer as a function of total pressure, temperature, and concentration of additive. It is seen that proton transfer occurs only to  $t-C_5H_{11}SH$ , and even in this case, proton transfer is a minor process. The major reaction observed with each of the four molecules is the formation of a condensation ion which dissociates rapidly to give ( $C_9H_{19}^+ + HX$ ) or ( $C_5H_{11}^+ +$  neutral products) where X is Cl, Br, OH, or SH. The formation of  $C_5H_{11}^+$  is favored under all conditions, but the formation of  $C_9H_{19}^+$  becomes more important as the pressure is raised or the temperature is lowered. When  $i-C_4D_{10}$  is substituted for  $i-C_4H_{10}$ , it is seen that in the mercaptan, where proton

transfer may be slightly exothermic, the departing hydrogen sulfide molecule carries away a D species from the reacting *tert*-butyl ion with a high probability; conversely, in  $t-C_5H_{11}Br$ , the departing hydrogen bromide molecule has a low probability of containing a hydrogen species from the reacting *tert*-butyl ion. This result suggests that when proton transfer competes with the displacement reaction, the two reactions proceed through the same intermediate ion, a  $C_9H_{20}X^+$  species, in which "internal" proton transfer has occurred. The product  $C_5H_{11}^+$  ion undergoes an analogous displacement reaction with all of these molecules to form the following as products: ( $C_{10}H_{21}^+ + HX$ ) and ( $C_6H_{13}^+ +$  neutral products). The  $C_6H_{13}^+$  product ion also undergoes a displacement reaction with all of these molecules to form as products ( $C_{11}H_{23}^+ + HX$ ).

**14491.** Sieck, L. W., Gorden, R., Jr., **Photoionization of simple hydrocarbons at 73.6–74.4 and 58.4 nm. Comparison with Penning ionization**, *Chem. Phys. Lett.* **19**, No. 4, 509–512 (Apr. 15, 1973).

Key words: energy transfer; hydrocarbons; ionic fragmentation; mass spectra; photoionization; unimolecular reactions.

Ionic fragmentation patterns have been determined for  $CH_4$ ,  $CD_4$ ,  $C_2H_2$ ,  $C_2H_6$ , and  $C_3H_8$  following photoabsorption at 73.6–74.4 (16.7–16.9 eV) and 58.4 nm (21.2 eV). These mass spectra have been compared with previous spectra obtained via Penning ionization processes involving collisions of these same molecules with metastable Ne (16.6–16.7 eV) and He (19.8–20.6 eV). On the basis of this comparison it is concluded that the molecular ions produced in Penning ionization have a higher internal energy content than is produced by photoionization at the same energy.

**14492.** Ausloos, P., Rebert, R. E., Lias, S. G., **Primary processes in the photolysis of propane: The use of HI as a radical scavenger**, *J. Photochem.* **2**, 267–283 (1973–74).

Key words: equipartition of energy; hydrogen iodide; methylene insertion reaction; propane; radical scavenging; vacuum ultraviolet photolysis.

The photolysis of  $C_3D_8$  has been investigated with 8.4, 10.0 and 11.6–11.8 eV photons, using HI to scavenge the radicals through the reaction:  $R_D + HI \rightarrow R_DH + I$  (where  $R_D$  is a fully deuterated alkyl or alkenyl radical). Comparison of the results with the results of analogous experiments using  $H_2S$  as a scavenger leads to the conclusion that HI is a more efficient radical scavenger than  $H_2S$ . The results are discussed with particular emphasis on determining whether the primary processes include direct C–C and C–H bond cleavage. An examination of the effects of HI concentration, conversion, and pressure on the yield of ethyl radicals intercepted indicates that the ethyl radicals are formed in the primary process:  $C_3D_8^* \rightarrow C_2D_5 + CD_3$ . It is noted that the relative importances of this process and the other primary processes involving breaking of the C–C bond ( $C_3D_8^* \rightarrow CD_4 + C_2D_4$  and  $C_3D_8^* \rightarrow C_2D_6 + CD_2$ ) do not change with energy, and it is thus suggested that they all occur from an excitation in the C–C bond, and that RRKM considerations relating to equipartition of energy are not applicable to the dissociations of electronically excited alkanes. It is pointed out that, as in the photolysis of *n*-thane, the dissociation leading to the formation of a molecule of hydrogen (deuterium) ( $C_3D_8^* \rightarrow D_2 + C_3D_6$ ), which apparently occurs as a result of an excitation in a C–H (C–D) bond, predominates in the 8.4 eV photolysis, but diminishes sharply in importance with respect to the C–C bond cleavage processes when the energy is increased. The insertion of methylene into a primary C–H bond of  $C_3H_8$  to give *n*-butane is examined, and information concerning the internal energy of the  $CH_2$  species is derived and discussed in terms of the primary dissociation of propane.



**14493.** Sze, W. C., Kotter, F. R., **The design of near-perfect instrument transformers of simple and inexpensive construction**, *J. Appl. Meas.* **2**, No. 1, 22-27 (Jan.-Feb. 1974).

Key words: current ratio; leakage impedance; magnetizing impedance; ratio error; single-stage transformer; two-stage transformer; voltage ratio.

A brief discussion of the causes of ratio errors in single- and two-stage transformers is presented. The design and construction of two simple two-stage transformers, which can be used in either the voltage or current mode with an accuracy better than 10 ppm in ratios over the frequency band of 50 to 2000 Hz are described. Multiple ratios are obtained by series-parallel interconnections of windings.

**14494.** Simmons, J. H., Mills, S. A., Napolitano, A., **Viscous flow in glass during phase separation**, *J. Amer. Ceram. Soc.* **57**, No. 3, 109-117 (Mar. 1974).

Key words: glass; microstructure; phase separation; viscosity.

The isothermal viscosities of two borosilicate glasses, one a commercial glass widely used for chemical glassware, increase by 4 to 5 orders of magnitude with heat-treatment time near the annealing point. The glasses are basically sodium borosilicates but differ greatly in phase-separation characteristics. Electron micrographs were used to analyze the development of microstructure during the suspected phase separation. In both glasses, structure development is primarily responsible for the viscosity increase. An analysis of the data and a theoretical interpretation of the effect are presented.

**14495.** Saunders, J. B., **Reflection, transmission and phase shift of light at imbedded optical films**, *J. Opt. Soc. Amer.* **62**, No. 1, 6-9 (Jan. 1972).

Key words: interferometry; Kösters prism; optical films; phase shift; polarized light; reflection; thin films; transmission.

Reflectance and transmittance of polarized light at imbedded optical films are measured for films of different compositions and thicknesses. The reflectance/transmittance ratio of plane-polarized light from such films, whose reflectance equals the transmittance at normal incidence, can be varied from approximately 1/3 to 4 by rotating the plane of polarization. A method is described that permits measurement of differences of phase shift, between reflected and transmitted light, for optical films imbedded in dielectric media that are approximately homogeneous. Phase-shift differences were obtained for two different aluminum films. Whereas values approximately  $\pi/2$  rad were expected, values of 106 and 74°, respectively, were found for light polarized parallel and perpendicular to the plane of incidence. The two interferograms, produced by light of these two polarizations, appear to be complementary. However, the two interferograms produced by either polarization and observed from opposite sides of the film are not complementary—thus indicating a variation of absorption of the film with optical-path difference.

**14496.** Schneider, S. J., McDaniel, C. L., **The BaO-Pt system in air**, *J. Amer. Ceram. Soc. Discussions and Notes* **52**, No. 9, 518-519 (Sept. 21, 1969).

Key words: BaO-Pt system; BaO-PtO<sub>2</sub> system; dissociation; phase equilibria.

The phase relations between BaO and Pt in air were studied by x-ray diffraction, differential thermal analysis, and quenching techniques. At lower temperatures the system can be represented by the BaO-PtO<sub>2</sub> pseudobinary. Prominent features of the system include a hexagonal 4BaO·PtO<sub>2</sub> compound, a phase of unknown composition and symmetry and a solid solution (orthorhombic) existing approximately between 33 and 50

mole % PtO<sub>2</sub> at 1025 °C. At higher temperatures all intermediate phases eventually dissociate to BaO and Pt. The dissociation temperature of PtO<sub>2</sub> in air was determined as 585 °C.

**14497.** Tiemann, E., **Isotope dependence of the rotational constant of sulfur monoxide in the <sup>3</sup>Σ-ground state**, *J. Mol. Spectrosc.* **51**, 316-320 (1974).

Key words: Born-Oppenheimer approximation; isotopic effects; microwave spectra; molecular parameters; rotational transitions; sulfur monoxide.

The rotational spectra of <sup>32</sup>S<sup>16</sup>O, <sup>34</sup>S<sup>16</sup>O and <sup>32</sup>S<sup>18</sup>O were measured. The rotational constant  $B_0$  was accurately determined for all three isotopes whereas the spin-spin coupling  $\lambda_0$  and the spin-rotation coupling  $\gamma_0$  have less accuracy due to the strong correlation of these constants for the observed transitions. The evaluated breakdown of the Born-Oppenheimer approximation can primarily be attributed to the nonadiabatic correction term found for <sup>1</sup>Σ-diatomic molecules. The small adiabatic correction for SO is obtained with the opposite sign as usually derived in <sup>1</sup>Σ-molecules.

**14498.** Weisman, H. M., **A survey on the use of National Standard Reference Data System publications**, *J. Chem. Doc.* **12**, No. 4, 211-216 (1972).

Key words: National Standard Reference Data System; properties data; survey; users.

The purpose of this mail survey to purchasers of National Standard Reference Data System publications was to assess what benefits the publications provided its users and to obtain feedback on user experience, requirements, and problems of use. Survey returns gave evidence that NSRDS publications were helpful to users in meeting their data requirements. Specific uses and benefits were identified. The greatest use of NSRDS publications was in connection with basic research. Because NSRDS compilations have utility in the applied areas as well, their usefulness needs to be promoted among applied workers and engineers.

**14499.** Clark, F. O., Johnson, D. R., **Magnetic fields in the Orion molecular cloud from the Zeeman effect in SO**, *Astrophys. J.* **191**, L87-L91 (July 15, 1974).

Key words: dense molecular clouds; magnetic field; Orion A; radio astronomy; sulfur monoxide; Zeeman effect.

Reported line widths of observed emission features from a variety of interstellar molecules are compared for the Orion A molecular cloud. All of the excess width observed for SO in Orion A is assumed to be due to Zeeman splitting of the energy levels in order to obtain an estimate of the upper limit for the ambient magnetic field in this source. From the available data, upper limit estimates yield a most probable value near 6 gauss for the magnetic field in the central feature of Orion A. This estimate can possibly be reduced by a factor of 2 or 3 if other effects such as kinematics are responsible for a portion of the observed widths. The implications of a field of this magnitude in a dense molecular cloud are discussed.

**14500.** Swing, R. E., **The optics of microdensitometry**, *Opt. Eng.* **12**, No. 6, 185-198 (Nov.-Dec. 1973).

Key words: linear optical systems; microdensitometry; optics; partial coherence.

A review of the current developments in microdensitometry is made, with emphasis on the investigations leading to the current level of understanding of optical performance. The classical microdensitometer is then analyzed according to the principles of the theory of partial coherence. Conditions for the insuring of linear operation are derived, and the idea of effective incoherence at the source aperture is presented with a discussion



of the implications. The various microdensitometer configurations are subjected to analysis, and the four possible variations (viz., overfilling, underfilling, with two possible locations for the sampling aperture) are thoroughly evaluated. The new concept of linear microdensitometry is discussed and summarized briefly. The current concerns of microdensitometry are then presented and considered. The restrictions on maximum sample frequency as a result of the partial coherence in the illumination is a major concern of this paper, and tables are presented for typical microdensitometer configurations that delineate the kinds of limitations that can be expected.

**14501.** Freeman, D. H., **Interactive gel networks for organic chemical separations**, *Isr. J. Chem.* **10**, 889-891 (1972).

Key words: chromatography; interactive gel; separations.

A comparison is drawn between the fundamental logic of the origin of ion exchange affinity, and that of the newly discovered behavior of interactive gels. The basis for predicting interactive chromatographic affinity is examined.

**14502.** Winzer, G. E., **National Bureau of Standards mobile acoustical laboratory**, *Sound Vib.* **4**, No. 5, 12-15 (May 1970).

Key words: acoustical instrumentation; architectural acoustics; building research; field measurements; noise control; sound measurements; sound transmission.

A mobile laboratory has been designed for research and measurement of the acoustical performance of buildings and for the study of environmental noise. The measurement capabilities are of the quality usually associated only with fixed acoustical laboratories. Data may be collected, reduced and analyzed in the field, or stored on magnetic tape for future reduction.

**14503.** Vomhof, D. W., Thomas, J. H., **Determination of moisture in starch hydrolyzates by near-infrared and infrared spectrophotometry**, *Anal. Chem.* **42**, No. 11, 1230-1233 (Sept. 1970).

Key words: hydrolyzates; infrared; moisture; near-infrared; spectrophotometry; starch.

Evidence is presented that the near-infrared method, employing either DMF or  $\text{Me}_2\text{SO}$  as the solvent, and the infrared method, with  $\text{Me}_2\text{SO}$  as the solvent, are quite applicable to the determination of the moisture content of starch hydrolyzates. The near-infrared method is superior in terms of both accuracy and precision to both the present vacuum-oven method and the infrared method. These methods do not seem to be influenced by the method of manufacture, the saccharide distribution, or the ash content. They are sufficiently rapid that they could be used for quality control both by manufacturers and users of corn syrups and solid sugars.

**14504.** Cezairliyan, A., **Simultaneous measurements of heat capacity, electric resistivity, and hemispherical total emittance of an alloy of niobium, tantalum, and tungsten in the range 1500 to 2800 K**, *J. Chem. Thermodyn.* **6**, 735-742 (1974).

Key words: electrical resistivity; emittance; high-speed measurements; high temperature; refractory alloy; specific heat; thermodynamics.

Simultaneous measurements of the heat capacity, electric resistivity, and hemispherical total emittance of an alloy of niobium, tantalum, and tungsten (nominal composition: 80 mass percent Nb, 10 mass percent Ta, and 10 mass percent W) in the temperature range 1500 to 2800 K by a sub-second-duration transient technique are described. Estimated inaccuracies of measured properties are: 3 percent for heat capacity, 5 percent for hemispherical total emittance, and 0.5 percent for electric resistivity. Properties of the alloy are compared with the properties of the constituent elements. The measured heat capacities are

approximately 2.6 percent (on the average) higher than the values computed according to Kopp's additivity law. Although this difference is within the combined estimated inaccuracies, it is higher than the combined estimated imprecision of the measurements. Therefore, the alloy probably departs from Kopp's law. The electric resistivities indicate a significant departure from Matthiessen's law. Like the major constituent niobium, the alloy showed a negative departure from linearity in the plot of electric resistivity against temperature.

**14505.** Rossmassler, S. A., **Public/private cooperation in planning and developing reference data programs**, *J. Chem. Doc.* **13**, No. 2, 65-68 (1973).

Key words: advisory services; consultation; cooperative programs, NSRDS; reference data.

The National Standard Reference Data System relies heavily on the advice of experts in special subject-areas of science and technology to plan and develop programs for compilation and evaluation of quantitative data. Advisory panels provide a means of bringing together generators and evaluators of data to define needs, recommend specific projects, determine priorities, and coordinate new activities with those already in process. Such advisory panels are the natural basis for the development of cooperative programs, not only for data compilation and evaluation, but also for improvement in the quality of original experimental work, standardization of techniques, and agreement on formats for the presentation of, e.g., spectroscopic data. While such panels are sponsored by the Federal Government, the panel membership includes people from universities, private industry, professional societies, and consultant organizations. The cooperative nature of the undertakings fosters attention to user needs and public benefits.

**14506.** Griffin, R. J., Jr., **Pointing the finger at burn safety**, *Ind. Res.* **16**, No. 6, 45 and 47 (June 1974).

Key words: burns; instrumentation; product safety; safety test.

Describes an instrument, developed by NBS, designed to test surfaces for burn hazards. Termed a "thermesthesiometer," the instrument is capable of duplicating the temperature that would be experienced by human contact to heated surfaces.

**14507.** Zapas, L. J., **Nonlinear behavior of polyisobutylene solutions**, (Proc. Battelle Colloquium on Deformation and Fracture of High Polymers, Kronberg, Germany, Sept. 11-16, 1972), Paper in *Deformation and Fracture of High Polymers*, H. H. Kausch, J. A. Hassell and R. I. Jaffee, Eds., pp. 381-395 (Plenum Press, New York, N.Y., 1974).

Key words: BKZ; nonlinear shear behavior; polyisobutylene.

Experiments on various histories of simple shear were obtained with a polyisobutylene solution. A possible inadequacy of the BKZ theory is presented, together with a modified theory whose predictions are in agreement with the experimental data.

**14508.** Walls, F. L., Dunn, G. H., **Storing ions for collision studies**, *Phys. Today* **27**, No. 8, 30-35 (Aug. 1974).

Key words: dissociative recombination; electron collisions; ion trap.

Overcoming the limitations of plasma and colliding beam techniques, the new ion storage methods have proved their effectiveness in ion recombination studies.

**14509.** Mayer, I., Roth, R. S., Brown, W. E., **Rare earth substituted fluoride-phosphate apatites**, *J. Solid State Chem.* **11**, 33-37 (1974).



Key words: crystal structure;  $\text{Ln}_x\text{M}_{10-2x}\text{Na}_x(\text{PO}_4)_6\text{F}_2$ ; rare earth apatites.

Compositions with the general formula  $\text{Ln}_x\text{M}_{10-2x}\text{Na}_x(\text{PO}_4)_6\text{F}_2$  ( $\text{Ln} = \text{La, Pr, Nd, Sm, Eu, Dy, Er, Lu,}$  and  $\text{Y}$ ;  $\text{M} = \text{Ca, Sr, and Ba}$ ) have been prepared and studied by x-ray diffraction methods. The hexagonal apatite like structure was indicated by the powder patterns of all the compounds (with  $\text{Ba}$  compounds only when  $\text{Ln} = \text{La}$  through  $\text{Sm}$ ). Single crystal precession data reveal that the crystal lattice of all the compositions in the  $\text{Ca}$  and  $\text{Sr}$  system have space group  $P6_3/m$ , the  $\text{Ln}_2\text{Ba}_6\text{Na}_2(\text{PO}_4)_6\text{F}_2$  compounds crystallize in space group  $P6$  and the  $\text{Ln}_3\text{Ba}_4\text{Na}_3(\text{PO}_4)_6\text{F}_2$  compounds in the trigonal space group  $P3$ . Order and disorder mechanisms of the substitution and its dependence on size and polarization effects are discussed.

**14510.** Ballard, D. B., **A low magnification-large sample holder for the SEM**, *Proc. 32d Annual Electron Microscope Society of America Meeting, St. Louis, Mo., Aug. 13-16, 1974*, pp. 446-447 (Aug. 1974).

Key words: large sample; low magnification; scanning electron microscope; stage.

A large specimen stage with low magnification capability was constructed to fit the SEM. The specimen can be rotated for stereo pair photographs. All modes of signal processing and SEM controls that are normally available can be used with this stage.

**14511.** Yates, J. T., Jr., King, D. A., **Chemisorption of carbon monoxide on tungsten: Correlation of reflection-absorption infrared spectra with CO binding state population**, *Surface Sci.* **30**, 601-616 (1972).

Key words: carbon monoxide; chemisorption; flash desorption; infrared spectroscopy; molecular vibration; tungsten.

The vibrational frequency of carbon monoxide chemisorbed on an atomically clean polycrystalline tungsten ribbon has been studied using reflectance-infrared spectroscopy and ultrahigh vacuum techniques. The initial appearance of an infrared absorption band at  $2093\text{ cm}^{-1}$  is unequivocally associated with the onset of adsorption of the weakly-bound  $\alpha\text{-CO}$  state, which occurs at coverages where the more strongly-bound  $\beta\text{-CO}$  species are already extensively populated. As the  $\alpha\text{-CO}$  coverage is increased to its maximum value, the infrared band shifts to  $2117\text{ cm}^{-1}$ . Partial thermal desorption of the  $\alpha\text{-CO}$  by pumping at  $295\text{ K}$  for  $\sim 2000\text{ sec}$  causes the band to reversibly shift back to  $\sim 2093\text{ cm}^{-1}$ . The band disappears rapidly and completely upon thermal desorption of  $\text{CO}$  at  $403\text{ K}$ , confirming that the absorption band observed in this region of the spectrum is due to  $\alpha\text{-CO}$ . The spectral frequency indicates that the  $\alpha\text{-CO}$  species on tungsten are closely analogous to the linear  $\text{CO}$  moieties found in transition metal carbonyls. The vibrational frequency observed is in close agreement with low energy electron energy-loss measurements made for  $\text{CO}$  on  $\text{W}(100)$ . A model is proposed for the slight strengthening of the carbon-oxygen bond in  $\alpha\text{-CO}$  as the  $\text{CO}$  coverage increases. The model involves coverage-dependent electronic back-donation from surface  $\text{W}$  atoms into  $\Pi$ -antibonding orbitals as originally proposed by Blyholder for adsorbed  $\text{CO}$ , and by Jones for certain transition metal hexacarbonyls.

**14512.** Yolken, H. T., **Standard reference materials and meaningful x-ray measurements**, (Proc. Denver X-Ray Conference, Denver, Colo., Aug. 21-23, 1973), Paper in *Advances in X-Ray Analysis*, C. L. Grant, C. S. Barrett, J. B. Newkirk, and C. O. Ruud, Eds., **17**, 1-15 (1974).

Key words: standard reference materials; x-ray calibration; x-ray measurements.

A review of the procedures and efforts at the National Bureau of Standards (NBS) to provide for meaningful measurements

through the use of Standard Reference Materials (SRM's) is presented.

The examples of NBS standardization efforts for x-ray analysis range from basic metrology to applied environmental measurements. These examples include a determination of x-ray wavelength by a method which in part utilizes simultaneous x-ray and optical interferometry measurements of the atomic planes of near perfect silicon. In addition, Standard Reference Materials (SRM's) are being developed and applied to trace element analysis using x-ray fluorescence techniques. These efforts include development of SRM's for trace element analysis of air particulates. In another area, work is proceeding on the development of a silicon powder Standard Reference Material intended for x-ray diffractometer calibration. An effort to develop a suitable x-ray diffraction technique to determine the amount of quartz in mine dust is also underway. NBS efforts to provide SRM's for the calibration of electron microprobes and the validating of correction factor calculations are also described.

**14513.** Wright, J. R., **Performance criteria in building**, *Sci. Amer.* **224**, No. 3, 16-25 (Mar. 1971).

Key words: agrément system; building code of New York State; building codes; human requirements; National Conference of States; performance approach; performance criteria; performance methodology; regulatory system.

The performance approach seeks the solution to building problems in terms of human requirement satisfaction, irrespective of the methods or materials employed. The approach has application both to the regulatory (building codes) system and to the full range of concerns in building, from research to design. The performance-oriented National Conference of States on Building Codes and Standards is expected to be instrumental in modernizing the regulatory system.

**14514.** Zief, M., Barnard, A. J., Jr., Rains, T. C., **Magnesium gluconate as a standard for the determination of serum magnesium**, *Clin. Chem.* **19**, No. 11, 1303-1304 (1973).

Key words: atomic absorption spectrometry; magnesium gluconate; serum magnesium; standard material.

Magnesium gluconate dihydrate has been prepared and tested as a source of material for a magnesium standard in atomic absorption spectrometry. This material meets the criteria for purity (99.9%), stability, weighing factor and flame characteristics and would serve as an ideal standard for serum magnesium. Magnesium gluconate dihydrate has a solubility of  $16\text{g}/100\text{ ml}$  of water at  $25^\circ\text{C}$  and can be acidified with a mineral acid to insure a long shelf life as a magnesium standard stock solution.

**14515.** Wu, Yung-Chi, **Young's mixture rule and its significance**, *J. Phys. Chem.* **74**, No. 21, 3781-3786 (1970).

Key words: electrolytes; excess thermodynamic properties of mixtures; mixture; ternary solutions; thermodynamics; Young's mixture rule.

Young's general mixing rule postulates that in the mixing of two binary solutions of the same ionic strength to produce a ternary solution an excess thermodynamic quantity of the ternary solution may be expressed accurately as the sum of the corresponding excess thermodynamic quantities of the pure binary solutions. Young's corollary to the general rule postulates further that deviations from the rule are a function both of the ionic strength and of the respective solute fractions of the mixture. In terms of Young's two postulates any mixing process at constant ionic strength may be treated as one of four special cases. Young's postulates may also be applied to ternary mixtures of different ionic strength in which the mixing ratio of the constituents is constant.



**14516.** Fraker, A. C., Ruff, A. W., Green, J. A. S., Bechtoldt, C. J., **Polarization measurements on titanium tube and sheet having preferred orientation textures**, *Corrosion* **30**, No. 6, 203-207 (June 1974).

Key words: corrosion; NaCl solution; passivation; sheet; sulfuric acid; titanium; tubing.

The influence of preferred orientation texture on the anodic polarization behavior of titanium tubing and sheet has been investigated. Potentiostatic polarization measurements were made on specimens in the annealed and deformed conditions during exposure to boiling NaCl solutions (pH=1) and to 1N H<sub>2</sub>SO<sub>4</sub> (pH=0.3) solutions at 23 °C (73 °F). Results were correlated with single crystal data, and it was found basal (0001) orientation texture has a marked effect on the anodic polarization of titanium, especially in the active region where this texture gives lower current densities. Polarization curves and examples of the microstructures are shown and discussed.

**14517.** Wu, Yung-Chi, **Material properties criteria for thermal safety**, *J. Mater.* **7**, No. 4, 573-579 (1972).

Key words: heat conduction; thermal inertia; thermal injury; thermal safety; thermal tissue damage.

The purpose of this study is to establish the relationship between the thermal properties of materials and thermal injury to human tissue. The interdependency of temperature and time to the conditions required for thermal safety is based on the physiological process of thermal injury. By the application of Fourier's heat equation, the relationship between the permissible temperature and time of contact of a heated body and its thermal properties is determined.

**14518.** Alexandropoulos, N. G., Cohen, G. G., Kuriyama, M., **Evidence of optical transitions in x-ray inelastic scattering spectra: Li metal**, *Phys. Rev. Lett.* **33**, No. 12, 699-702 (Sept. 16, 1974).

Key words: Compton scattering; lithium; optical transitions; x-ray inelastic scattering; x-ray Raman scattering.

We report results of x-ray Compton-Raman scattering experiments. In addition to the expected Compton and Raman scattering, there is a prominent feature in the form of a peak near  $E/E_F=1$ . The new peak can be explained qualitatively by considering the conduction band of lithium metal to be composed of hybridized orbital electrons, and it furnishes the first evidence of an *L*-x-ray Raman band.

**14519.** Orvini, E., Gills, T. E., LaFleur, P. D., **Method for determination of selenium, arsenic, zinc, cadmium, and mercury in environmental matrices by neutron activation analysis**, *Anal. Chem.* **46**, No. 9, 1294-1297 (Aug. 1974).

Key words: activation analysis; arsenic; cadmium; environment; mercury; pollution; radiochemical separations; selenium.

A procedure has been developed for the simultaneous determination of selenium, arsenic, zinc, cadmium, and mercury in different environmental matrices. The radiochemical separation method involves the combustion of the samples, followed by reduction with carbon monoxide and volatilization of the metals at high temperature. The method was initially tested with radiotracer experiments; then by analyzing some NBS Standard Reference Materials. The procedure has been used to determine the Se, As, Zn, Cd and Hg concentration of some new Standard Reference Materials being prepared by the National Bureau of Standards.

**14520.** Peterson, R. L., Day, G. W., Gruzensky, P. M., Phelan, R. J., Jr., **Analysis of response of pyroelectric optical detectors**, *J. Appl. Phys.* **45**, No. 8, 3296-3303 (Aug. 1974).

Key words: detectors; gold-blacks; optical radiation detectors; optics; polymers; pyroelectric detectors; pyroelectricity; self-calibrated detectors.

Several configurations of pyroelectric optical-radiation detectors are mathematically modeled to determine their frequency response and current response to step-function heat inputs. Included in the analysis are heat losses by conduction and reradiation, effects of absorptive coatings, and an experimentally observed nonuniformity of polarization through the thickness of polymer pyroelectric films. Roll-off of the frequency response at both low and high frequencies is carefully examined. Curve fitting to response data allows a quantitative determination of the pyroelectric coefficient and the degree of nonuniformity of the polarization. The thermal conductivities of gold blacks used as absorbers are determined from the high-frequency data together with independent measurements of the black thicknesses and densities. The total emissivity of evaporated nickel films sometimes used as absorbers can be estimated from the low-frequency data. The difference in response to optical and electrical heat inputs is examined as a part of our effort in fabricating electrically self-calibrating optical detectors.

**14521.** Pardoe, G. W. F., Larson, S. J., Gebbie, H. A., Strickler, S. J., Ingham, K. D., Johnson, D. G., **Far-infrared spectrum of ortho-xylene**, *J. Chem. Phys. Letters to Editor* **52**, 6426-6427 (1970).

Key words: far infrared; ortho-xylene; torsional vibration.

Far infrared measurements have been made on ortho-xylene in the liquid and vapor phases. A band in the region of 180 cm<sup>-1</sup> is plausibly assigned to a torsional vibration of methyl groups.

**14522.** Snyder, W. F., **Lord Kelvin on atoms as fundamental natural standards (for base units)**, *IEEE Trans. Instrum. Meas.* **IM-22**, No. 1, 99, (Mar. 1973).

Key words: atomic frequency standards; fundamental standards; Lord Kelvin; Maxwell; natural standards; wavelength standards.

In the 1879 edition of *Elements of Natural Philosophy*, Lord Kelvin stated, at the suggestion of Maxwell, that atoms of hydrogen and sodium could serve as natural standards of time (frequency) and length. This was a far-sighted view in terms of recent developments of atomic frequency standards and the use of wavelengths of light as length standards.

**14523.** Young, R. D., **Surface microtopography**, *Phys. Today* **24**, No. 11, 42-49 (Nov. 1971).

Key words: microscope; microtopography; single-crystal surface; surface; surface finish; surface profile.

The growing field of surface science would benefit considerably from measurements of surface microtopography down to the atomic level. A brief review is presented of several instruments used to quantitatively characterize the surface microtopography of metallic surfaces. Techniques are discussed for employing the transmission electron microscope, the scanning electron microscope, the optical interference microscope and an engineering profile measuring instrument to measure surfaces suitable for surface science experiments. In addition a new noncontacting instrument which is presently under development will be described. It is concluded that several techniques are presently available for detecting single atom steps on single-crystal surfaces.

**14524.** Boyle, D. R., Clague, F. R., Reeve, G. R., Wait, D. F., Kanda, M., **An automated precision noise figure measurement system at 60 GHz**, *IEEE Trans. Instrum. Meas.* **IM-21**, No. 4, 543-549 (Nov. 1972).

Key words: analysis; automation; noise figure; Y-factor.



As part of a millimeter-wave development program at the National Bureau of Standards, a precision measurement method and system was devised to automatically measure the effective input noise temperature of 55-65-GHz receivers.

Salient features of the system include a bolometric  $Y$ -factor measurement, a working "hot" noise source consisting of a waveguide argon gas tube mount developed at the National Bureau of Standards, and a minicomputer system controller operating in Basic. System design considerations and measurement uncertainties are discussed.

**14525.** Schafft, H. A., **Failure analysis of wire bonds**, *Proc. 11th Annual IEEE Reliability Physics Symp., Las Vegas, Nev., April 3-5, 1973, IEEE Catalog No. 73CHO 755-9PHY*, pp. 98-104 (1973).

Key words: electrical connection; failure analysis; inter-metallic compounds; Kirkendall voids; microelectronics; reliability; semiconductor devices; wire bond.

Failure analysis of wire bonds has an important part to play in determining the causes of microelectronic device failure and ways for making and using devices to achieve greater reliability. Several tests and procedures used in the failure analysis of wire bonds are reviewed. Some of the inferences about possible causes of permanent or intermittent failure that can be drawn from such tests, particularly those involving inspection with an optical microscope and with a scanning electron microscope, are discussed. Some attention is paid to the effects on the reliability of the wire bond of the growth of gold-aluminum intermetallic compounds, of Kirkendall voids, and of the use of poor materials, poor processes in making the wire bond, and poor control over the processes used. Also reviewed are some metallurgical sectioning techniques and a variety of methods used in opening the commonly used packages and in exposing wire bonds that are encapsulated in epoxy, phenolic resin, or silicone materials.

**14526.** Blair, W., Iverson, W. P., Brinckman, F. E., **Application of a gas chromatograph—atomic absorption detection system to a survey of mercury transformations by Chesapeake Bay microorganisms**, *Chemosphere III*, No. 4, 167-174 (1974).

Key words: anaerobic bacteria; atomic absorption; Chesapeake Bay; dimethylmercury; estuary; facultative bacteria; gas chromatography; mercury; metabolites; methylmercury; sediments.

A flameless atomic absorption spectrophotometer coupled to a vapor phase chromatograph was developed which permits speciation of elemental mercury ( $\text{Hg}^0$ ) methylmercury ( $\text{CH}_3\text{HgCl}$ ), and dimethylmercury in gaseous metabolites at environmental concentrations. Through use of this technique, a number of mercury tolerant anaerobic and aerobic bacteria, isolated from Chesapeake Bay sediments, were examined for their ability to produce these compounds in the presence of  $\text{Hg}$  as  $\text{HgCl}_2$  (1 ppm). Of the two facultative isolates examined in a  $\text{N}_2$  atmosphere, one produced both methylmercury and  $\text{Hg}^0$  and the other only  $\text{Hg}^0$ . In the presence of air only one of these organisms produced slight traces of  $\text{Hg}^0$ . Of the five anaerobic isolates, one produced  $\text{Hg}^0$ , methylmercury, and dimethylmercury, two produced only  $\text{Hg}^0$ , and two evolved only very slight or no detectable traces of  $\text{Hg}^0$ . These and previous results are consistent with the view that biomethylation of  $\text{Hg}$  is a more likely process under anoxic conditions.

**14527.** Moldover, M. R., **Visual observation of the critical temperature and density:  $\text{CO}_2$  and  $\text{C}_2\text{H}_4$** , *J. Chem. Phys.* **61**, No. 5, 1766-1778 (Sept. 1, 1974).

Key words:  $\text{C}_2\text{H}_4$ ; carbon dioxide;  $\text{CO}_2$ ; critical density; critical point; critical temperature; ethylene; temperature reference point.

The critical temperature ( $T_c$ ) and density ( $\rho_c$ ) of carbon dioxide ( $\text{CO}_2$ ) and ethylene ( $\text{C}_2\text{H}_4$ ) have been determined by a modern version of the classical technique of visual observation of the disappearance of the meniscus. We discuss in some detail what a "visual observation of the disappearance of the meniscus" is, a subject that is relevant to the possible use of critical temperatures as secondary temperature reference points. For  $\text{CO}_2$  we find  $T_c = 30.977 \pm 0.004$  °C and  $\rho_c = 0.4678 \pm 0.0022$  g/cm<sup>3</sup>. For  $\text{C}_2\text{H}_4$  we find  $T_c = 9.194 \pm 0.004$  °C and  $\rho_c = 0.2146 \pm 0.0006$  g/cm<sup>3</sup>. The errors quoted for  $\rho_c$  are two standard deviations from a fit to an assumed symmetrical scaling equation of state. The errors quoted for  $T_c$  are an "estimated" limit of error. A comparison of the values of  $T_c$  which we have measured with recent PVT data yields new values for the critical pressures ( $P_c$ ). We find that  $P_c = 73.753$  bar (72.789 atm) for  $\text{CO}_2$  and  $P_c = 50.390$  bar (49.731 atm) for  $\text{C}_2\text{H}_4$ .

**14528.** Iverson, W. P., **Biological corrosion**, Chapter in *Advances in Corrosion Science and Technology*, M. G. Fontana and R. W. Staehle, Eds., **2**, 1-42 (Plenum Press, New York, N.Y., 1972).

Key words: algae; bacteria; biological corrosion; fungi; mechanisms; prevention; review.

A review article of biological corrosion. Includes a brief historical outline, a discussion of the organisms involved in, the mechanism of and methods for preventing biological corrosion. The organisms associated with biological corrosion include fungi, bacteria and algae. The bacteria involved in sulfur and iron transformations, the "sulfur" and "iron" bacteria are among the most important organisms involved in biological corrosion. The mechanisms reviewed include the formation of acids, sulfur and sulfur compounds, ammonia and other corrosive compounds by microorganisms, formation of differential oxygen and chemical concentration cells, cathodic depolarization, disruption of protective films and breakdown of corrosion inhibitors. The methods for control and prevention of biological corrosion discussed include proper selection of a suitable environment, modification of a corrosive environment, the use of microbial inhibitors, and the use of protective coatings and cathodic protection separately or jointly.

**14529.** Bagg, T. C., Editor, **A report of the micrographic Goodwill People-to-People tour through Europe, including the Soviet Union**, *J. Microgr.* **6**, No. 5, 219-229 (May-June 1973) and **6**, No. 6, 269-279 (July-Aug. 1973).

Key words: microfilm; libraries; microfiche; overseas.

During the fall of 1972 the National Microfilm Association organized and coordinated a delegation of 12 members and 8 of their wives on a visit to Europe and Soviet Union as part of the Goodwill People-to-People Program. The purpose of this trip was to give micrographic leaders in the U.S. an opportunity to meet their overseas counterparts. The major cities visited were, the Hague, Brussels, Paris, Prague, Moscow, Belgrade and London. This report consists of brief discussions by various delegates of the many professional groups visited.

**14530.** Schooley, J. F., **Superconductive transition in cadmium**, *J. Low Temp. Phys.* **12**, Nos. 5/6, 421-437 (1973).

Key words: cryogenics; pure cadmium; reproducibility; superconductivity; thermometric fixed point; transition temperature; transition widths.

Mutual inductance measurements of the superconductive transitions occurring in single-crystal and polycrystalline cadmium samples in magnetic fields of  $0-10^{-4}T$  ( $0-1$  G) are presented. The temperature at which the zero-field superconductive transition midpoints occur appears to be constant within  $\pm 0.2$  mK for transitions narrower than 2 mK, but  $T_c$  increases for broader transitions. The transitions exhibited both narrowing



and hysteresis, the latter perhaps due to supercooling, in fields of a few tenths of a gauss.  $T_c$  has been measured as  $0.515 \pm 0.002_5$  K on the  $T_{62}$  temperature scale.

- 14531.** Phelan, R. J., Peterson, R. L., Klein, G. P., Hamilton, C. A., Day, G. W., **Absolute, pyroelectric radiometers and two dimensional arrays**, *Proc. American Electro-Optical Systems Design Conference, New York, N.Y., Sept. 18-20, 1973*, pp. 117-123 (1973).

Key words: IR detectors; polyvinylfluoride; pyroelectrics; radiometers.

In pursuit of useful techniques for measurements of laser power and beam profiles, we have been developing some pyroelectric detector devices and systems. The power measurements are based on electrical substitution techniques and thus do not require standard optical sources. The beam profiles have been measured using two axis mirror scanners with a single detector, single axis scanners with linear arrays, and two dimensional arrays of pyroelectrics. We will briefly discuss the general calibration scheme to indicate why we are using pyroelectrics, give some of the properties of pyroelectrics, give some of the details of device construction, describe a few systems and give some experimental results.

- 14532.** Finnegan, T. F., Wahlsten, S., **Microwave emission from coupled Josephson junctions**, (Proc. 13th Int. Conf. on Low Temperature Physics-LT 13, Boulder, Colo., Aug. 21-25, 1972), Paper in *Low Temperature Physics-LT 13*, K. D. Timmerhaus, W. J. O'Sullivan, and E. F. Hammel, Eds., **3**, 272-275 (Plenum Publishing Corp., New York, N.Y., 1974).

Key words: ac Josephson effect; frequency-pulling; tunnel-junction array.

Recently, much interest has developed in the possibility of using large arrays of Josephson junctions for various applications. To this end, the properties of the microwave radiation emitted by a pair of coupled Josephson tunnel junctions connected permanently in series but independently current biased have been investigated experimentally. The detected coherent radiation emitted by the individual junctions when biased on the self-resonant voltage steps was between  $10^{-13}$  and  $10^{-10}$  watts. When both junctions were biased to radiate at the same frequency, the radiation from the junctions combined coherently in one of two ways: (1) The total radiation was unusually large as would occur if the oscillations of the two junctions were in phase. When the bias point of one of the junctions was varied slightly, frequency-pulling and phase-locking effects were directly observed. (2) The total radiation was unusually small as would occur if the oscillations of the two junctions were out of phase (with a relative phase difference of  $\pi$ ). The details of these results are discussed.

- 14533.** Saunders, J. B., **A simple interferometric method for workshop testing of optics**, *Appl. Opt.* **9**, No. 7, 1623-1629 (July 1970).

Key words: interferometry; optical shop testing; shearing interferometer; testing of optics.

A simple step-by-step method is given for deriving the shapes of wavefronts from data obtained with a wavefront shearing interferometer. No mathematics, other than arithmetic, is used. The result is the accurate deviation of the wavefront from a reference sphere that coincides with it at three chosen reference points. The method is intended primarily for the use of opticians in optical workshops, but is also quite practical for the final testing of optics for performance rating. A method is given by which an optician can evaluate an optical surface by comparing the interferogram produced by it and a known prism interferometer, with a drawing of the desired interferogram. This procedure is

analogous to using test plates for visual inspection of optical surfaces.

- 14534.** Simiu, E., **Wind spectra and dynamic alongwind response**, *J. Struct. Div. Proc. Amer. Soc. Civil Eng.* **100**, No. ST9 1897-1910 (Sept. 1974).

Key words: acceleration; aerodynamics; building (codes); deflection; dynamic structural analysis; pressure; spectra; structural engineering; tall buildings; turbulence; wind (meteorology).

Current methods for determining dynamic alongwind response are based on the assumption that turbulence spectra are independent of height. The adequacy of this assumption is assessed in the light of recent theoretical and experimental results of boundary layer meteorology. Expressions for the alongwind response, including deflections and accelerations, are proposed. It is shown that, in the case of tall, flexible, lightly damped structures (i.e., of structures for which the resonant response, as defined by Davenport and Vickery, is high), expressions of the spectrum which reflect its dependence upon height yield lower values of the alongwind fluctuating response than the expression currently used in building codes and standards, in which this dependence is ignored. Results of numerical calculations show that the values of the fluctuating deflections and of the gust factors obtained if the latter expression is used may be higher by as much as 50 and 25 percent, respectively, than those obtained if the variation of spectra with height is taken into account.

- 14535.** Wright, R. N., Kramer, S., **Buildings in the 1972 Managua earthquake**, *Mil. Eng.* **65**, No. 428, 382-388 (Nov.-Dec. 1973).

Key words: building; building codes; earthquakes; hazards; natural disasters; structures.

Following the Managua, Nicaragua earthquake of December 23, 1972, a team of engineers representing the U.S. Department of Commerce's National Bureau of Standards and the National Academy of Engineering performed field investigations in Managua, Nicaragua, from December 26, 1972 to January 4, 1973. The objectives were to assist the Nicaraguan government in surveying major buildings to determine whether each was suitable for emergency use, repairable, or appropriate for clearance. The team also viewed the patterns of successful performance and damage to identify needs for improvements in building practices for mitigation of earthquake hazards and opportunities for more detailed investigations which could provide information for future improvements in practices.

The Managua earthquake, estimated at Richter magnitude 6.25, was not a great earthquake, but the loss of life approached 10,000, approximately 75 percent of Managua's 450,000 occupants were rendered homeless, and property damages are estimated to approach \$1 billion. In general, these damages cannot be attributed to unusual intensities of ground shaking or severity of surface faulting. Most damages appeared to result from deficiencies in building practices; deficiencies which had been exhibited many times before in previous earthquakes, deficiencies which would be avoided by implementation of up-to-date provisions for earthquake resistant design and construction. However, Managua did not employ a building code with seismic design requirements appropriate to its earthquake risk, and furthermore, did not have a building regulatory system capable of effective implementation of its building code provisions.

The Managuan experience may serve as an incentive to improvement of building practices in many other areas which are subject to substantial earthquake risks and have not consistently accounted for these risks in their building codes and building regulatory system.

- 14536.** Sakuma, E., Evenson, K. M., **Characteristics of tungsten-nickel point contact diodes used as laser harmonic-generator**



mixers, *IEEE J. Quantum Electron.* **QE-10**, No. 8, 599-603 (Aug. 1974).

Key words: laser harmonic generator-mixer; tungsten-nickel point contact diodes.

Properties of tungsten-nickel point contact diodes, when used as harmonic-generator mixers, were measured. The measured properties are those which will be useful to workers wishing to use these high-speed devices (faster than  $10^{-14}$  s). Some of the properties measured were: the decrease in signal with mixing order; the detected signal as a function of laser frequency; and the power required to optimize the harmonic beat notes.

**14537.** Rains, T. C., Menis, O., **Determination of submicrogram amounts of mercury in standard reference materials by flameless atomic absorption spectrometry**, *J. Ass. Offic. Anal. Chem.* **55**, No. 6, 1339-1344 (1972).

Key words: flameless atomic absorption; liver and coal; loss of mercury; mercury in orchard leaves; standard reference materials.

In a study of the flameless atomic absorption method for the determination of nanogram amounts of mercury in organic materials, the technique was improved to provide greater precision and accuracy. The loss of mercury during the digestion of organic materials with nitric, sulfuric, and perchloric acids is prevented by controlled heating and a packed refluxing column. The reduction and absorption system was simplified by using a heated absorption cell which alleviates the interference of volatile vapors. This method has been applied to the determination of mercury in NBS standard reference materials of orchard leaves, liver, and coal, and the results were compared with results obtained with two other analytical methods.

**14538.** Merris, R. L., Pierce, S., **The Bell numbers and  $r$ -fold transitivity**, *J. Combinatorial Theory* **12**, No. 1, 155-157 (Jan. 1972).

Key words: Bell numbers; permutation group;  $r$ -fold transitivity; Stirling numbers.

Let  $G$  be a permutation group of order  $|G|$  acting on a set of  $n$  elements. For  $g \in G$ , let  $\theta(g)$  be the number of elements left fixed by  $g$ . Then, for  $1 \leq r \leq n$ ,

$$\sum_{g \in G} (\theta(g))^r > X_r |G|$$

with equality if and only if  $G$  is  $r$ -fold transitive. Here,  $X_r$  is the  $r$ -th Bell number.

**14539.** Huie, R. E., Herron, J. T., **The rate constant for the reaction  $O_3 + NO_2 \rightarrow O_2 + NO_3$  over the temperature range 259-362 K**, *Chem. Phys. Lett.* **27**, No. 3, 411-414 (Aug. 1, 1974).

Key words: air pollution; nitrogen dioxide; ozone; rate constant; stratosphere.

The rate constant for the reaction of ozone with nitrogen dioxide has been measured over the temperature range 259 to 362 K, using a stopped-flow system coupled to a beam sampling mass spectrometer. A fit of the data to the Arrhenius equation gave:  $k = (9.44 \pm 2.46) \times 10^{10} \exp[(-2509 \pm 76)/T]$   $\text{cm}^3 \text{mol}^{-1} \text{sec}^{-1}$ .

**14540.** Dickens, B., Schroeder, L. W., Brown, W. E., **Crystallographic studies of the role of Mg as a stabilizing impurity in  $\beta$ - $\text{Ca}_3(\text{PO}_4)_2$ . I. The crystal structure of pure  $\beta$ - $\text{Ca}_3(\text{PO}_4)_2$** , *J. Solid State Chem.* **10**, 232-248 (1974).

Key words: beta tricalcium phosphates; cation vacancies; positional disorder; single crystal; x-ray diffraction.

$\beta$ - $\text{Ca}_3(\text{PO}_4)_2$  crystallizes in the rhombohedral space group  $R\bar{3}c$  with unit cell parameters  $a = 10.439(1)$ ,  $c = 37.375(6)$  Å (hexagonal setting) and cell contents of 21  $[\text{Ca}_3(\text{PO}_4)_2]$ . The

structure was refined to  $R_w = 0.026$ ,  $R = 0.030$  using 1143 x-ray intensities collected from a single crystal by counter methods. Corrections were made for absorption, secondary extinction, and anomalous dispersion.

The structure is related to that of  $\text{Ba}_3(\text{VO}_4)_2$ , but has lower symmetry because of the widely different ionic sizes of Ca and Ba. Seven  $[\text{Ca}_3(\text{PO}_4)_2]$  units occupy a volume corresponding to eight  $[\text{Ba}_3(\text{PO}_4)_2]$  units. The requirement of the  $c$  glide in  $\beta$ - $\text{Ca}_3(\text{PO}_4)_2$  has been shown in the least squares refinements to be attained by disorder of one cation over two sites. This disorder has a far-reaching effect on the structure.

**14541.** Powell, C. J., **Internal x-ray photoemission in aluminum: Excitation of electrons from the valence band**, *Solid State Commun.* **10**, No. 12, 1161-1164 (1972).

Key words: aluminum; density of states; photoelectron energy distribution; x-ray photoemission.

Measurements are reported of Al valence-electron excitation by  $K\alpha_{1,2}$  x-rays internally generated in evaporated specimens by electron bombardment. The x-ray photoelectron energy distribution is consistent with the u.v. distributions of Huen and Wooten. Weak structures are found in the energy distribution at positions corresponding to those in the calculated density of states.

**14542.** Merris, R., Pierce, S., **Monotonicity of positive semidefinite hermitian matrices**, *Proc. Amer. Math. Soc.* **31**, No. 2, 437-440 (Feb. 1972).

Key words: character; Kronecker power; symmetric group; tensor power.

Inequalities which compare elements of the convex cone of positive semidefinite hermitian matrices with products of roots of elements are proved. They yield inequalities for Schur functions (generalized matrix functions) which, when specialized to the determinant, give a result of R. Bellman and L. Mirsky.

**14543.** Meshkov, S., **How good are symmetry predictions?** (Proc. Int. Conf. on Symmetries and Quark Models, Wayne State University, Detroit, Mich., June 18-20, 1969), Paper in *Proceedings of the International Conference on Symmetries and Quark Models*, R. Chand, Ed., pp. 199-209 (Gordon and Breach, New York, N.Y., 1970).

Key words: exotic; mesons; reactions; structure;  $\text{SU}(6)_W$ ; symmetry.

A summary discussion of the comparison of experiment and  $\text{SU}(6)_W$  reaction predictions is presented.

**14544.** Yap, W., **Binding of ions to oligopeptides**, *Biophys. J.* **13**, 1160-1165 (1973).

Key words: ion binding; nearest-neighbor interaction; oligopeptide; titration curve.

A model for the binding of ions to oligopeptides, in which nearest neighbor interactions are considered is developed. Equations for the titration curves are derived. The apparent association constants are determined as a function of the degree of polymerization and of the interactions between nearest neighbors.

**14545.** Nyyssonen, D., **Partial coherence in imaging systems**, *Opt. Eng.* **13**, No. 4, 362-367 (July-Aug. 1974).

Key words: coherence measurement; microdensitometry; optical imaging; partial coherence.

An improved method of measuring spatial coherence is described and some sources of measurement errors are discussed. Partial coherence in the image plane of an optical system is discussed and results of coherence measurements are given that demonstrate the scaling of the coherence function for



coherence intervals large compared to the diameter of the Airy disk and the limiting value for the coherence interval equal to the diameter of the Airy disk. The application of these results to microdensitometry is discussed and results of coherence measurements in the source plane of currently-used classical microdensitometers are given.

**14546.** Sawyer, D. E., **Prevalent error sources in transistor delay-time measurements**, (Proc. Annual Conf. on Nuclear and Space Radiation Effects, Seattle, Wash., July 24-27, 1972), *IEEE Trans. Nucl. Sci.* NS-19, No. 6, 121-124 (Dec. 1972).

Key words: delay time; measurement errors; radiation effects; transistors.

Measurements of bipolar transistor delay times are extensively employed to predict neutron vulnerability. Of the various possible delay times, phase delay is most commonly measured. Although this is the simplest delay measurement to implement, the measurement circuit may be quite susceptible to extraneous signal coupling at the measurement frequency and this can cause the accuracy to be severely degraded. A technique for minimizing this delay-time error has been developed. It employs simple, preferably nonreactive, but at least known, networks in place of the transistor. From the differences between the "delay times" measured on these known networks, the location and magnitude of the error sources in the circuit are found. This allows one to reduce greatly the effects of the error sources on all subsequent measurements.

To confirm the theory of the error-correcting technique, RC networks with known delay times were assembled on transistor headers. For a particular bridge configuration, the uncorrected delay times measured were quite frequency dependent, but this dependence was removed by adding a correction term to the delay times. The correction term is obtained from measurements on the nonreactive networks and does not at all depend on the measured RC network delay times.

The effects of error-sources are particularly severe when transistors with low or moderate  $h_{fe}$  values are measured, as when measurements are made on transistors that have been degraded by subjecting them to neutron radiation. The delay time then observed may show significant frequency-dependence, but, as for the measurement described on the RC networks, this dependence is the signature of the measurement system rather than the transistor, and may be removed by adding an independently-obtained correction term. In the absence of this correction, erroneous conclusions may be reached as to the effects of the radiation on the devices under test.

**14547.** Powell, C. J., **Structure on the high-energy side of the  $KL_{23}M$  Auger peak from solid aluminum: Internal photoemission**, *Appl. Phys. Lett.* 20, No. 9, 335-337 (May 1, 1972).

Key words: aluminum; Auger-peak; secondary-electron energy distribution; x-ray photoemission.

Some weak structure on the high-energy side of the  $L_{23}MM$  Auger peaks for Al and Si has been recently interpreted as being possibly due to the simultaneous decay of an inner-shell vacancy and a volume plasmon. It is shown here that similar structure due to multiple ionization is to be expected and that photoemission caused by internally generated x rays can be observed if the fluorescent yield is not too small. Relatively strong structure of the latter type has been observed in the secondary-electron energy distribution of evaporated Al on the high-energy side of the  $KL_{23}M$  Auger peak.

**14548.** Kurylo, M. J., Braun, W., Kaldor, A., **A laser enhanced reaction technique for the measurement of  $V \rightarrow T$  deactivation rates: Deactivation of vibrationally excited  $O_3$** , *Chem. Phys. Lett.* 27, No. 2, 249-253 (July 15, 1974).

Key words: apparatus and methods; deactivation; energy transfer; infrared laser; luminescence; ozone.

Rates of  $V \rightarrow T$  transfer for vibrationally excited ozone ( $O_3^+$ ) in the (100), (010) and (001) levels have been measured using a laser enhanced chemiluminescent method for the deactivating gases He, Ar,  $H_2$ ,  $N_2$ ,  $O_2$ ,  $H_2O$ ,  $CO_2$ ,  $SO_2$ ,  $CH_4$ , and  $SF_6$ . The method takes advantage of an enhanced reaction rate between  $O_3^+ + NO$  producing electronically excited  $NO_2$  and uses the  $NO_2$  chemiluminescence as a tracer for the  $O_3^+$  concentration. Results obtained by this new method are compared with recent results obtained by an IR fluorescence method. Good agreement is obtained for all gases, except methane, and implications of these results on the mechanism for deactivation are described.

**14549.** Braun, W., Kurylo, M. J., Kaldor, A., Wayne, R. P., **Infrared laser enhanced reactions: Spectral distribution of the  $NO_2$  chemiluminescence produced in the reaction of vibrationally excited  $O_3$  with  $NO$** , *J. Chem. Phys.* 61, No. 2, 461-464 (July 15, 1974).

Key words: chemiluminescence reaction; emitting state; enhanced reaction; infrared laser; spectral distribution; vibrationally excited.

Vibrationally excited ozone, produced by  $CO_2$  laser radiation, was found to react significantly faster with  $NO$  than does thermal  $O_3$ . The emission spectrum of the laser enhanced chemiluminescence from this reaction was measured from 520 to 810 nm. The lowest lying  $1^2B_2$  state was identified as the primary source of  $NO^*_2$  emission in the  $NO + O_3$  reaction. One quantum of vibrational excitation in the reactant  $O_3$  was found to introduce one quantum of vibrational energy in the product  $NO_2$  ( $1^2B_2$ ). The rate enhancement of the reaction channel producing  $NO_2(1^2B_2)$  as a result of vibrational excitation of  $O_3$  was  $5.6 \pm 1.0$ . Thus, only about 50 percent of the available vibrational energy is used to enhance this reaction.

**14550.** Eliason, L. K., Isler, M. A., Stenbakken, G. N., **Mercury switches for burglar alarm systems**, *NILECJ-STD-0303.00*, 13 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., May 1974).

Key words: burglar alarm sensor; burglar alarm system; interior perimeter sensor; mercury; switch.

This standard establishes performance criteria for mercury switches intended for use in protective intrusion alarm circuits to monitor the position of doors, windows, etc. These devices cause the initiation of an alarm signal to a police panel, central station, or local audible alarm device. Included are requirements and test methods for performance, electrical properties and materials. The characteristics addressed are those which affect the reliability of the device with emphasis on those performance characteristics which affect its false alarm susceptibility. This standard does not provide performance criteria concerning the ability of these devices to resist attempts to defeat them through physical or surreptitious attack.

**14551.** Richmond, J. C., **Test procedures for night vision devices**, *LESP-RPT-0302.00*, 21 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., July 1974).

Key words: contrast transfer function; distortion; flare; light equivalent background; light induced background; night vision devices; optical gain; test methods.

This report includes descriptions of the test procedures that will be used for testing image intensifier night vision devices of the passive type, in a project sponsored by the Law Enforcement Standards Laboratory at NBS. These same procedures,



modified, if necessary, in the light of experience gained in testing a number of the night vision devices, will be incorporated in a Standard for such devices.

- 14552.** Treado, M. J., Taggart, H. E., Nelson, R. E., Workman, J. L., **Mobile antennas**, *NILECJ-STD-0205.00*, 9 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., May 1974).

Key words: antenna; communications; law enforcement; mobile; standard; transceiver.

This standard establishes minimum performance requirements and methods of test for mobile antennas mounted in vehicles which are used by law enforcement agencies.

- 14553.** Dobbyn, R. C., Calvano, N. J., **Portable ballistic shields**, *NILECJ-STD-0103.00*, 7 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., May 1974).

Key words: armor; ballistic shields; standard.

The purpose of this document is to establish performance requirements and a method of test for the ballistic resistance of portable ballistic shields intended to protect against small arms fire.

- 14554.** Nicholson, W. L., **Some revised approaches to x-ray crystal structure analysis calculations**, (Proc. Conf. Critical Evaluation of Chemical and Physical Structural Information, Dartmouth, College, Hanover, N.H., (June 24-29, 1973), Paper in *Critical Evaluation of Chemical and Physical Structural Information*, D. R. Lide, Jr. and M. A. Paul, Eds., pp. 45-47 (National Academy of Sciences, Washington, D.C., 1974).

Key words: least squares; robust techniques; statistics.

This note is a progress report on a reanalysis of the International Union of Crystallography (IUCr) Single-Crystal Intensity Measurement Project on d(+)-tartaric acid. X-ray structure factor data are currently being analyzed by classic least squares procedures with complex pseudo-theoretical model components to account for observed inadequacies of the classic model, a linear combination of Gaussian characteristic functions. The purpose of the present reanalysis is to illustrate that introduction of terms for systematic error into the classic model and use of fitting techniques not crucially dependent on the Gaussian error assumption may bring the results of supposedly discrepant collaborative studies into agreement.

- 14555.** Malmberg, M. S., Kryder, S. J., Maryott, A. A., **Vapor phase dielectric relaxation spectra and dipole moments of paraldehyde and cis-1,3,5-trimethylcyclohexane**, *J. Chem. Phys. Letters to Editor* **61**, No. 6, 2476-2477 (Sept. 15, 1974).

Key words: cis-1,3,5-trimethylcyclohexane; dielectric; dipole moment; gas; microwave absorption; paraldehyde; relaxation.

Vapor phase dielectric relaxation spectra are obtained from measurements of microwave nonresonant absorption for paraldehyde and cis-1,3,5-trimethylcyclohexane. Gas dipole moments are found to be  $1.43 \pm .02$  D and  $0.25 \pm .01$  D respectively.

- 14556.** Howard, C. J., Evenson, K. M., **Laser magnetic resonance study of the gas phase reactions of OH with CO, NO, and NO<sub>2</sub>**, *J. Chem. Phys.* **61**, No. 5, 1943-1952 (Sept. 1, 1974).

Key words: gas phase reactions of OH with CO, NO, and NO<sub>2</sub>; laser magnetic resonance; rate constant.

A laser magnetic resonance spectrometer has been used in combination with a discharge-flow system to measure the gas

phase reaction rates of the OH radical with CO, NO, and NO<sub>2</sub> at 296 K and over a pressure range 0.4 – 5 torr. For the bimolecular reaction  $\text{OH} + \text{CO} \rightarrow \text{CO}_2 + \text{H}$  we measure a rate constant,  $k = 1.56 \times 10^{-13}$  cm<sup>3</sup>/molecule·sec. For the termolecular reactions  $\text{OH} + \text{NO} + M \rightarrow \text{HNO}_2 + M$ ,  $M = \text{He}$ ,  $k = 4.0 \times 10^{-31}$  cm<sup>6</sup>/molecule<sup>2</sup>·sec;  $M = \text{Ar}$ ,  $k = 4.4 \times 10^{-31}$  cm<sup>6</sup>/molecule<sup>2</sup>·sec;  $M = \text{N}_2$ ,  $k = 7.8 \times 10^{-31}$  cm<sup>6</sup>/molecule<sup>2</sup>·sec. For the reaction  $\text{OH} + \text{NO}_2 + \text{N}_2 \rightarrow \text{HNO}_3 + \text{N}_2$ ,  $k = 2.9 \times 10^{-30}$  cm<sup>6</sup>/molecule<sup>2</sup>·sec. Laser magnetic resonance detection of radicals is shown to be extremely sensitive, linear, and versatile. A complete description of this technique is presented with a discussion of its potential in the study of the reactions of free radicals.

- 14557.** Miller, E. F., Jr., Lindamood, G. E., **Structured programming: Top-down approach**, *Datamation* **19**, No. 12, 55-57 (Dec. 1973).

Key words: GOTO statements; hierarchical design; programming; structured programming; top-down design.

Structured programming is the topic of considerable current interest and discussion in computing circles. This informal, tutorial article explains the basic concepts of structured programming—GOTO-less programming, top-down design, and abstract resources—and traces their origins.

- 14558.** Sullivan, D. B., Dziuba, R. F., **Low temperature direct current comparators**, *Rev. Sci. Instrum.* **45**, No. 4, 517-519 (Apr. 1974).

Key words: current comparator; current ratio; shielding; superconductivity; transformer.

This paper presents an improved version of the low temperature direct current comparator described originally by Harvey. The comparator described herein exhibits a resolution of 1.5 nA·turn and provides ratios which have uncertainties of less than 4 parts in 10<sup>10</sup>. An alternate approach to the shielding of the windings is discussed and a preliminary comparator based on this concept is shown to have equally good performance. The latter comparator is probably better suited to the attainment of large current ratios.

- 14559.** Mies, F. H., **Ultraviolet fluorescent pumping of OH 18-centimeter radiation in comets**, *Astrophys. J.* **191**, L145-L148 (Aug. 1, 1974).

Key words: comet; fluorescence; OH; optical pumping; radiowave spectrum.

In the absence of collisions, optical pumping of cometary OH by solar ultraviolet radiation determines the relative population of OH molecules in the  $\Lambda$ -doubled levels of the  $^2\Pi_{3/2}$  ground state. The distribution is extremely sensitive to the heliocentric radial velocity of the comet, and at appropriate velocities the level populations will be either inverted or anti-inverted. Thus the OH 18-cm spectrum of a comet, measured with respect to the 10 K galactic background at 1665 and 1667 MHz, may be observed either in *emission* or in *absorption* at different periods during the trajectory. Optical pumping also will produce an alignment of the magnetic sublevels along the axis of the incident solar radiation, and variable degrees of linear polarization are expected.

- 14560.** Ely, J. F., Straty, G. C., **Dielectric constants and molar polarizabilities of saturated and compressed fluid nitrogen**, *J. Chem. Phys.* **61**, No. 4, 1480-1485 (Aug. 15, 1974).

Key words: Clausius-Mossotti function; dielectric constant; dielectric virial coefficients; molar polarizability; nitrogen; saturated liquid densities.

In this paper we present accurate, wide range measurements of the dielectric constant of saturated and compressed fluid nitrogen. Measurements were made from 65 to 125 K along the



saturated liquid boundary and along selected liquid and gaseous isotherms ranging from 92 to 300 K at pressures to 34.5 MPa. Densities ranged from the dilute gas to nearly three times the critical density. Molar polarizabilities, thought to be accurate to better than 0.10 percent, were calculated by combining the dielectric constant measurements with densities obtained from least-squares analyses of experimental  $pVT$  data. A correlation function based on selected experimental data is given for the saturated liquid densities. Dielectric virial coefficients, derived from the calculated molar polarizabilities, are also presented.

- 14561.** Van Brunt, R. J., Lawrence, G. M., Kieffer, L. J., Slater, J. M., **Electron energy dependence of the kinetic energy and angular distributions of  $O^+$  from dissociative ionization of  $O_2$** , *J. Chem. Phys.* **61**, No. 5, 2032-2037 (Sept. 1, 1974).

Key words: dissociation; electron impact; ionization; oxygen.

The electron energy dependence of the kinetic energy and angular distributions of  $O^+$  have been measured for the process of dissociative ionization of  $O_2$ . The kinetic energy distributions for energies above 0.5 eV are compared with other dissociative ionization measurements as well as results of dissociative photoionization and dissociative excitation by electrons leading to production of Rydberg excited neutral fragments. Angular distributions are interpreted in terms of symmetries of possible molecular ion states contributing to dissociation, and the results near threshold are compared with recent measurements of  $O^-$  from dissociative ion pair formation in  $O_2$ . Information about the states of excitation of the dissociation fragments as a function of ion energy is obtained from appearance potential measurements. The results indicate that predissociation may be important and that dissociative ionization of  $O_2$  is in general a complicated process involving many  $O_2^+$  states.

- 14562.** Madey, T. E., Yates, J. T., Jr., Erickson, N. E., **Use of x-ray photoelectron spectroscopy for studies of gases chemisorbed on metals**, *Electron. Fisc. Apl.* **17**, Nos. 1-2, 190-192 (1974).

Key words: carbon monoxide; chemical shifts; chemisorption; ESCA; nitric oxide; oxygen; photoelectron spectroscopy.

X-ray photoelectron spectroscopy (ESCA) has been used in a study of  $O_2$ , NO and CO adsorbed on polycrystalline tungsten. The adsorption and oxidation studies were carried out under ultrahigh vacuum conditions. Chemical shifts of several eV in the  $O(1s)$  spectra for each of these adsorbates were found to be correlated with different modes of bonding between adsorbate and substrate. In general, the core level binding energies associated with adsorbed species are smaller than the binding energies for the same atoms in small gaseous molecules.

- 14563.** Jacox, M. E., Milligan, D. E., **Matrix-isolation study of the vibrational spectrum and structure of the  $CO_3^-$  radical anion**, *J. Mol. Spectrosc.* **52**, 363-379 (1974).

Key words: charge transfer;  $CO_2^-$ ;  $CO_3^-$ ;  $CO_3^{2-}$ ; infrared spectrum; K atom reactions; matrix isolation; molecular structure;  $N_2O + CO_2^-$  reaction;  $O^- + CO_2$  reaction;  $O_2^- + CO$  reaction.

Charge-transfer interaction processes which occur upon codeposition at 14 K of an  $Ar:CO_2:N_2O$  or an  $Ar:CO:O_2$  mixture with an atomic beam of potassium lead to the stabilization of  $CO_3^-$  in the solid deposit. Infrared spectroscopic data require a  $C_{2v}$  structure for this molecule. Although the deviation of the structure from the expected  $D_{3h}$  symmetry may result in part from Jahn-Teller distortion, cation interactions have been found to play a significant role. Evidence is presented for the initial formation of  $CO_3^-$  with trigonal symmetry. Upon mercury-arc irradiation of the deposit, absorptions due to  $CO_3^{2-}$  grow in importance.

- 14564.** Wright, J. R., **Building research in the National Bureau of Standards (U.S.A.): How it relates to other Federal agencies and to industry**, *Proc. 2d South African Building Research Congress, Johannesburg, South Africa, May 5-8, 1969*, Paper No. S4/2, 1-23 (May 1969).

Key words: building research; building standards; measurement techniques; performance requirements.

The National Bureau of Standards (NBS) is the central measurement laboratory for the USA, covering the entire spectrum of the physical sciences and many fields of engineering. NBS serves as the focal point in the Federal Government for assuring maximum application of the physical sciences and engineering to the advancement of technology in industry and commerce. Building research constitutes a major activity and is carried out primarily in the Building Research Division of the Institute for Applied Technology, NBS. The Division conducts scientific and technical investigations of the chemical, physical, and engineering properties of building materials, components and systems, and their interaction with the building occupants, as a basis for defining the performance requirements and the measurement techniques required to better adapt the physical and functional characteristics of buildings to user needs. The Division provides laboratory and field support to: Federal agencies concerned with building construction and technology; public and private organizations that draft, promulgate and distribute building standards and codes; and the building industry, primarily to stimulate industrial innovation in building systems. The building research program is sufficiently basic to maintain a resource capability yet flexible enough to assist with the practical problems of 35 Federal agencies that construct buildings. The building industry is supported in a major way through technical-committee activities (285 separate memberships), consultation, publication, and direct laboratory research (Industry Associates program). The relationship of the NBS building research program to industry and to other Federal agencies is presented, covering problem selection, research programs and results, implementation of output, and effectiveness feedback.

- 14565.** Wall, L. A., Straus, S., Florin, R. E., Fetters, L. J., **Pyrolysis of anionic and thermally prepared polystyrenes**, (Paper presented at American Chemical Society Meeting, New York, N.Y., Aug. 28-31, 1972), *Polym. Prepr. Amer. Chem. Soc. Div. Polym. Chem.* **13**, No. 2, 1044-1045 (Aug. 1972).

Key words: anionic polystyrene; molecular weight distributions; polymers; polystyrene degradation; pyrolysis.

The changes in molecular weights and their distributions during pyrolysis have been examined for a series of polystyrenes prepared by thermal and anionic procedures. The initial rates of weight loss for the thermal polymer showed a 0.25 power dependence on the reciprocal of the number average molecular weight, while the anionic polymer showed zero dependence. The information obtained and previous results can be explained to a very large extent by a kinetic chain decomposition comprised of competing end and random initiation, depropagation, intra- and inter-molecular transfer and termination by combination.

For thermal polystyrenes the ratio of rate constants for random to end initiation has a value of  $3 \times 10^{-4}$  initially. The present treatment assumes this value is constant with conversion. On the other hand the anionic polymers initiate at random in the limit of zero time, after which end-initiation begins to occur, as the number of ends increases. The inter-molecular transfer constant, zip length and kinetic chain length are dependent on the steady state radical concentration and are functions of the molecular weight. Their values, at the molecular weights present when the pyrolytic weight loss exceeds 5 percent, agree well with earlier estimates.



**14566.** Zapas, L. J., **Non-linear behavior of concentrated polymer solutions**, (Paper presented at American Chemical Society Meeting, Atlantic City, N. J., Sept. 1974), *Polym. Prepr. Amer. Chem. Soc. Div. Polym. Chem.* **15**, No. 2, 131-136 (Sept. 1974).

Key words: BKZ theory; concentrated solutions; nonlinear behavior; polyisobutylene; polystyrene; superposition.

A phenomenological approach based on the elastic fluid theory of Bernstein, Kearsley and Zapas is discussed, with respect to the shear behavior of concentrated solutions. For certain systems a concentration superposition scheme can be found which covers the linear and nonlinear region. This is true only when the nonlinear stress relaxation modulus can be represented as a product of a function of time and a function of strain.

**14567.** Mount, G. H., Linsky, J. L., **One- and multi-component models of the upper photosphere based on molecular spectra. III: CH(O,O)  $\lambda$ 3144 of the CH C-X system**, *Solar Phys.* **36**, No. 2, 287-298 (June 1974).

Key words: best-fit model; carbon abundance; molecular spectra; upper photosphere.

We have obtained accurate center-to-limb photoelectric spectra of the CH(0,0) C-X bandhead region  $\lambda$ 3143-3148 Å at Kitt Peak National Observatory. From these spectra and a detailed analysis of the formation of the CH(0,0) spectrum we demonstrate that the best-fit upper photospheric model derived from our previous analyses of CN(0,0) and CN(1,1) spectra adequately explains the CH C-X observations. In addition we derive a solar carbon abundance of  $\log A_c = 8.30 \pm 0.20$  compared to the HSRA value of  $\log A_c = 8.55$ . This confirms our previous CN analyses which demonstrated that if the HSRA nitrogen abundance of  $\log A_N = 7.93 \pm 0.10$  is assumed, then  $\log A_c = 8.20 \pm 0.10$ . We also specify the regions of formation for the CH(0,0)  $\lambda$ 3143.47 Å bandhead at disc center and limb.

**14568.** Siddiqi, A. A., Chen, C. T., Meisels, G. G., Gorden, R., Jr., **On the ionization efficiencies of  $C_4H_8$  isomers at 123.6 nm**, *J. Chem. Phys. Letters to Editor* **57**, No. 10, 4506-4507 (Nov. 15, 1972).

Key words: butene; ionization efficiency; isomers; krypton resonance line; quantum yield; ultraviolet.

The ionization efficiencies of the  $C_4H_8$  isomers were determined at the krypton resonance line at 123.6 nm using total absorption and attenuation techniques. Average ionization efficiencies (ionization quantum yields) obtained independently in both laboratories are: isobutene, 0.206, 1-butene, 0.201, *cis*-2-butene, 0.201, *trans*-2-butene, 0.268, methylcyclopropane, 0.136, and cyclobutane, 0.0022.

**14569.** Sebastian, K. J., Nelson, C. A.,  **$|\Delta I| = 1/2$  rule from the symmetric quark model**, *Phys. Rev. D* **8**, No. 9, 3144-3161 (Nov. 1, 1973).

Key words: color-quark model; current algebra and pcac; nonleptonic  $\Omega^-$  decays; paraquark model; symmetric quark model; three-triplet quark model.

Two topics are treated in this paper: the explanation of the  $|\Delta I| = 1/2$  rule based on the symmetric quark model and the tests for this explanation in  $\Omega^-$  nonleptonic decays. From the "color-quark," the three-triplet, and the paraquark models, the  $|\Delta I| = 1/2$  rule follows for the octet-hyperon, the  $\Omega^-$ , and the kaon weak nonleptonic decays as a consequence of current algebra, pion PCAC (partially conserved axial-vector current), and dispersion relations. Gronau's successful numerical results for the octet-hyperon decay amplitudes also follow in these alternatives to the Bose-quark model. However, though the origin of both explanations is the Fierz reshuffling property of the  $V \pm A$  interactions, the explanations of the  $|\Delta I| = 1/2$  rule are quite distinct, e.g., in

the Bose-quark model this rule is *exact* whereas in the other versions it is only *approximate*, being violated by continuum contributions to the absorptive parts. Because  $\langle 0 | \mathcal{H}_w | K \rangle$  and  $\langle \pi | \mathcal{H}_w | K \rangle$  vanish in the symmetric quark model, the usual current-algebra soft-pion argument for  $|\Delta I| = 1/2$  rule and the  $K^*$ -pole-dominance assumption (as a Feynman diagram) for  $K_1^0 \rightarrow 2\pi$  are *not* convincing. On the other hand, the ordinary Fermi-quark model supplemented with octet dominance can be excluded, as it predicts  $D/F = 3$  in the SU(3) limit for the matrix element of the parity-conserving Hamiltonian for two baryons in the nucleon octet ( $D/F \approx -0.85$  from  $P$ -wave fits). The  $\Lambda K^-$  decay mode of the  $\Omega^-$  should be *predominantly*  $P$  wave (parity-conserving), whereas the  $\Xi \pi$  mode should have the  $P$  wave strongly *suppressed* and comparable to the  $D$  wave (parity-violating). This implies  $\Gamma(\Omega^- \rightarrow \Xi \pi) / \Gamma(\Omega^- \rightarrow \Lambda K^-) \ll 1$ . The estimated total  $\Omega^-$  decay rate is consistent with the present experimental number.

**14570.** Brown, D. W., Lowry, R. E., Wall, L. A., **Glass and melting transitions of copolymers of tetrafluoroethylene with propylene and isobutylene**, *J. Polym. Sci. Part A-2* **12**, 1303-1318 (1974).

Key words: copolymer; fluoropolymer; glass temperature; isobutylene; melting temperature; polymer; propylene; tetrafluoroethylene.

Copolymers of tetrafluoroethylene and propylene were prepared that contained 30-65 mole-percent of the former. Reactivity ratios of tetrafluoroethylene- and propylene-ended radicals are 0.008 and 0.06, respectively, resulting in formation of highly alternating copolymers. The glass temperatures,  $T_g$ , were determined using a differential scanning calorimeter. Values ranged from 260 to 275 K. A plot of  $T_g$  versus composition has a low maximum centered about the equimolar composition. Copolymers of tetrafluoroethylene and isobutylene were prepared that contained 30-56 mole-percent of the former. Reactivity ratios of tetrafluoroethylene- and isobutylene-ended radicals are 0.005 and 0.021, respectively. The glass temperatures of these copolymers range 257 to 313 K. A higher maximum at the equimolar composition is obtained when  $T_g$  is plotted versus composition. Isobutylene-containing copolymers having 45-54 mole-percent tetrafluoroethylene are crystalline. Melting temperatures range from 416 to 476 K and have their maximum value at the equimolar composition. It is thought that long sequences of alternating units behave as a third entity in these copolymers, the other two being nonalternating units of the two monomers. Unless inhibited, ionic homopolymerization of isobutylene can be appreciable, sometimes resulting in the polymer having two  $T_g$ .

**14571.** Steiner, B., **Conference on photometry and colorimetry, Zlatni Piasatsi, 27-30 June 1973**, *Appl. Opt. Meeting Reports* **12**, No. 12, 2992-2993 (Dec. 1973).

Key words: colorimetry; photometry; review.

A personal view of the International Conference on Photometry and Colorimetry in Varna is given for inclusion in the meeting report column of Applied Optics.

**14572.** Wyckoff, J. M., Pruitt, J. S., Svensson, G., **Dose vs. angle and depth produced by 20 to 100 MeV electrons incident on thick targets**, (Proc. Int. Congress on Protection against Accelerator and Space Radiation, Cern, Geneva, Switzerland, Apr. 26-30, 1971), *Health Phys. CERN* **71-16**, **2**, 773-797 (July 1, 1971).

Key words: electrons; MeV electrons; targets; thick targets.

When energetic electrons strike a thick target a number of processes lead to photons, electrons and neutrons leaving that target. The dose produced by this emerging radiation has been measured as a function of angle and depth in a polymethyl-



methacrylate phantom for incident 20 to 100 MeV electrons. While this is a special geometry, it is fairly typical and the general nature of the distribution may be of interest in planning of exposure and shielding against exposure. The measurement technique, involving the use of a large number of small thermoluminescent dosimeters, is shown to produce results that compare very favorably with recent calculations made for the particular 30 MeV electron target conditions.

- 14573.** Ross, P. D., Goldberg, R. N., **A scanning microcalorimeter for thermally induced transitions in solution**, *Thermochemica Acta* **10**, 143-151 (1974).

**Key words:** biopolymer transitions; calorimetry; chemical instrumentation; dipalmitoyl L- $\alpha$ -lecithin; microcalorimeter; thermochemistry.

A scanning microcalorimeter for the measurement of energies of transition in solution is described. The calorimeter utilizes semi-conductor thermoelectric modules and is of a very simple and inexpensive construction. The imprecision of measurement is three percent when measuring 25 to 250 mJ of heat associated with transitions over temperature intervals of up to 8 K. The calorimeter operates from ambient to 90 °C.

- 14574.** Waterstrat, R. M., Dickens, B., **Atomic ordering in a 15-type phases in the vanadium-nickel and vanadium-cobalt systems**, *J. Appl. Phys.* **45**, No. 9, 3726-3728 (Sept. 1974).

**Key words:** A 15 phases; atomic ordering; magnetic structure; neutron diffraction; superconductivity; vanadium alloys.

Atomic ordering in the V-Ni and V-Co A 15-type phases has been studied using neutron diffraction. The V-Ni Structure is shown to be ordered to the maximum extent permitted by the "off stoichiometric" composition,  $V_{77.5}Ni_{22.5}$ . The V-Co structure possessing the "ideal" composition  $V_{75.0}Co_{25.0}$  is also highly ordered. However, the V-Co diffraction data are less accurate due to neutron absorption by the cobalt atoms and interference from the sample holder. No magnetic structures were detected in the V-Co phase at 4.2 K.

- 14575.** Leep, D., Gallagher, A., **Electron excitation of the lithium 6708-Å resonance line**, *Phys. Rev. A* **10**, No. 4, 1082-1090 (Oct. 1974).

**Key words:** electron excitation; lithium.

We have measured the relative optical excitation function and the polarization of the 6708-Å line, using crossed beams of electrons and lithium-6, for electron energies from threshold to 1400 eV. The electron energy resolution was  $\sim 0.25$  eV, and the lithium-beam optical depth was small and varied. We have normalized our excitation function to Born theory at 1404 eV, where the energy dependence has converged to the theoretical behavior. Between 2 and 6 eV, the measured cross section is (10-45)percent smaller than the results of the most recent close-coupling calculations, but the measured polarization  $P$  agrees with these theories within 20 percent of  $P$ . The theoretical polarization at threshold is not observed with our energy resolution.

- 14576.** Wiederhorn, S. M., Evans, A. G., Fuller, E. R., Johnson, H., **Application of fracture mechanics to space-shuttle windows**, *J. Amer. Ceram. Soc.* **57**, No. 7, 319-323 (July 1974).

**Key words:** fracture; glass; proof testing; static fatigue; stress corrosion.

The fracture properties of an ultralow-expansion glass intended for use in windows for the Space Shuttle were characterized by strength and fracture-mechanics techniques to provide reliable design data. Proof-test diagrams for predicting minimum times-to-failure under specified service loads were developed

from measurements of subcritical crack growth in water and air. Failure predictions were confirmed from strength measurements in water. In vacuum ( $< 10^{-4}$  torr), the fracture behavior was similar to that of other high-SiO<sub>2</sub> glasses, as evidenced by the absence of subcritical crack growth and by insensitivity of the critical stress intensity factor to temperature.

- 14577.** Evans, A. G., Linzer, M., Russell, L. R., **Acoustic emission and crack propagation in polycrystalline alumina**, *Mater. Sci. Eng.* **15**, 253-261 (1974).

**Key words:** acoustic emission; alumina; crack propagation; failure prediction; microcracking.

Acoustic emission is measured during the fracture of polycrystalline alumina. It is shown that acoustic emission is obtained during macrocrack growth, which can be used for failure indication. Acoustic emission is also obtained owing to the formation of non-propagating grain size microcracks at the surface. This emission can mask that due to macrocrack growth, but only for short failure times or at high stresses. Models are presented which relate the acoustic emission to the various crack propagation processes.

- 14578.** Evans, A. G., Wiederhorn, S. M., **Proof testing of ceramic materials—an analytical basis for failure prediction**, *Int. J. Fract.* **10**, No. 3, 379-392 (Sept. 1974).

**Key words:** ceramics; failure probability; minimum time-to-failure; proof stress diagrams; proof testing.

An analysis is presented which permits the accurate prediction of component lifetimes after proof testing. The analysis applies to crack propagation controlled fracture but can be used as a conservative prediction when crack initiation is predominant. The analytical predictions are confirmed in a series of time-to-failure measurements.

- 14579.** Wiederhorn, S. M., Johnson, H., Diness, A. M., Heuer, A. H., **Fracture of glass in vacuum**, *J. Amer. Ceram. Soc.* **57**, No. 8, 336-341 (Aug. 1974).

**Key words:** crack propagation; fracture; fracture mechanics; glass; strength.

The fracture of 6 glasses was studied in vacuum,  $< 10^{-4}$  torr ( $10^{-2}$  N/m<sup>2</sup>), as a function of temperature from 25 to 775 °C. Subcritical crack growth was observed in 4 of the glasses. Activation energies for crack motion ranged from 60 to 176 kcal/mol. The glasses which did not exhibit slow crack growth were "anomalous" glasses with abnormal thermal and elastic properties. Critical stress intensity factors for these 2 glasses increased  $\approx 10$  percent as the temperature increased to  $\approx 600$  °C. It is felt that subcritical crack growth is not the result of alkali-ion diffusion or viscous flow but rather of a thermally activated growth process which depends on the crack-tip structure in the glass. A narrow cohesive region at the crack tip favors subcritical crack growth, whereas a wide region favors abrupt fracture.

- 14580.** Hoer, C. A., **The 6-port coupler; a new approach to measuring V, I, P, Z, and  $\theta$** , (Summary), (Proc. Conf. Digest on Precision Electromagnetic Measurements, Boulder, Colo., June 26-29, 1972), *CPEM Digest*, pp. 15-17 (1972).

**Key words:** current; directional coupler; impedance; phase; power; voltage.

A 6-port coupler is described having four side arms whose outputs are proportional to the voltage, current, incident voltage wave, and reflected voltage wave at some desired measurement plane in the transmission line. The phase relationship between the outputs is the same as between corresponding quantities at the measurement plane. Complex impedance and phase angle as well as voltage, current, and power can be obtained from simple power or voltage magnitude measurements at the four side arms.



**14581.** Levine, J., **Precision long-path interferometry and its application to geophysics and astrophysics**, (Proc. Conf. Digest on Precision Electromagnetic Measurements, Boulder, Colo., June 26-29, 1972), *CPEM Digest*, p. 115 (1972).

Key words: geophysics; interferometry; saturated absorption stabilizer; strainmeter.

We are currently operating a 30-meter Fabry-Perot interferometer as a strainmeter in an unworked gold mine near Boulder, Colorado. The interferometer is illuminated by a 3.39  $\mu\text{m}$  single mode helium-neon laser. The laser is locked to one of the transmission maxima of the Fabry-Perot by means of a servo loop which tunes the laser so as to maximize the power transmitted through the long path. The tuning is accomplished by mounting one of the laser mirrors on a piezoelectric ceramic and by applying a suitable voltage to the ceramic.

**14582.** Benjamin, E. A., **A review of methods and requirements for fire protection of steel-framed buildings**, *Proc. Structural Engineering Association of California, Coronado, Calif., Oct. 3, 1968*, pp. 24-28 (1968).

Key words: building codes; E-119 test; fire protection; fire research; steel construction.

Developments in materials and techniques to meet the current building code requirements for fire protection of steel-framed buildings are described. Included is a discussion of some of the test requirements in the ASTM Standard, Methods of Fire Tests of Building Construction and Materials. Research work that may lead to improvement in the Fire Test Method is described.

**14583.** Wyckoff, J. M., **Measurements for radiation safety**, *Proc. 19th Annual Meeting of the Institute of Environmental Sciences, Anaheim, Calif., Apr. 2-5, 1973*, pp. 130-135 (1973).

Key words: government agencies; measurement assurance program; permissible limits; radiation; regulations; standards; transfer standards.

Good measurements are the key to safe application of both ionizing and nonionizing radiation in industry, medicine and consumer products. The National Bureau of Standards, as the Nation's primary source of physical measurement capability, is expanding its measurement services to radiation users. At the same time, it works closely with federal regulatory agencies such as AEC, BRH, NIOSH, and EPA to assist them in preparation of regulations containing realistic measurement requirements. The state of the measurement art in x-ray, nuclide, ultraviolet, laser, electromagnetic and ultrasonic radiation measurements will be reviewed highlighting the need for stable and accurate transfer standards to serve the safety community.

**14584.** Warkulwiz, V. P., Mozer, B., Green, M. S., **Observation of the deviation from Ornstein-Zernike theory in the critical scattering of neutrons from neon**, *Phys. Rev. Lett.* **32**, No. 25, 1410-1413 (June 24, 1974).

Key words: critical exponent  $\eta$ ; critical point; critical scattering; neon; neutron diffraction; Ornstein-Zernike.

A deviation from the Ornstein-Zernike theory of critical scattering has been observed in a neutron-diffraction study of neon near its critical point. The critical exponent  $\eta$  was determined to have the value  $0.11_{-0.02}^{+0.03}$ .

**14585.** Mabie, C. P., **Adhesive refractory protective coating for investment casting**, *J. Dent. Res.* **53**, No. 5, 1181-1188 (Sept.-Oct. 1974).

Key words: casting; coat; dental; investment; refractory.

A refractory protective coat has been developed that greatly reduces scale formation and is capable of lowering sandblasted casting roughness 30 to 50 percent. When applied as a thin film

to the refractory model, it remains as a tacky base which will fix wax and plastic.

**14586.** Hahn, T. A., Kirby, R. K., **Thermal expansion of a borosilicate glass from 80 to 680 K—Standard Reference Material 731**, (Proc. AIP Conf. on Thermal Expansion, Lake of the Ozarks, Mo., Nov. 7-9, 1973), Paper in *AIP Conference Proceedings No. 17, Thermal Expansions, 1973*, R. E. Taylor and G. L. Denman, Eds., No. 17, 93-101 (American Institute of Physics, New York, N.Y., 1974).

Key words: borosilicate glass; dilatometer calibration; standard reference material; thermal expansion.

This Borosilicate Glass is the third Standard Reference Material (SRM) to be certified for thermal expansion measurements by the National Bureau of Standards. Copper (SRM 736) and Fused Silica (SRM 739) are the other two materials. The results of tests on six samples taken from the stock will be reported in this paper. These results indicate the stock to be of consistent quality suitable for certification. Measurements were made in the temperature range from 80 to 680 K using an interferometer apparatus. At 293 K the expansivity is  $4.78 \times 10^{-6} \text{ K}^{-1}$  and the standard deviation is  $0.06 \times 10^{-6} \text{ K}^{-1}$  calculated from a least squares fit to the data over the entire temperature range. A description of the calibration of a fused quartz dilatometer using the three Standard Reference Materials will also be presented.

**14587.** Yonemura, G. T., **Opponent-color-theory treatment of the CIE 1960 (u,v) diagram: Chromaticness difference and constant-hue loci**, *J. Opt. Soc. Amer.* **60**, No. 10, 1407-1409 (Oct. 1970). (Oct. 1970).

Key words: chromaticity diagram; color difference; color hue; color theory.

An angular interpretation of the CIE 1960 (u,v) system is presented. This new development of the CIE 1964 (u,v) ( $U^*$ ,  $V^*$ ,  $W^*$ ) system results in improved chromaticness-difference predictions and is more in accord with empirical constant-hue loci than the  $U^*$ ,  $V^*$ ,  $W^*$  system.

**14588.** Scott, W. W., Jr., **A new coaxial RF-DC ammeter, (Summary)**, (Proc. Conf. Digest on Precision Electromagnetic Measurements, Boulder, Colo., June 2-5, 1970), Special Issue *CPEM Digest*, p. 13 (1970).

Key words: ammeter; compensation; radio-frequency; RF-DC difference; standard; thermal-current-converter; thermopile.

A small, portable reference standard of radio-frequency current has been developed which, when calibrated with the NBS Standard Electrodynamometer, will serve as an interlaboratory standard of high accuracy between NBS and users in industry.

The ammeter is unique and has no precedence in principle of operation. It consists of an elliptic cylindrical silver reflector of infrared energy with a cylindrical thin-film quartz heater along one focus and a heat sensing thermopile along the other focus.

The ammeter has three times the current range of older ammeters with up to ten times larger output and unequalled broadband frequency range. The prototype covers 0.5 ampere to 5 amperes (heater burnout at about 9 amperes) with corresponding dc outputs from 1 millivolt to 100 millivolts for currents in the frequency range dc to 1 GHz.

**14589.** Marzetta, L. A., **A thermesthesiometer—an instrument for burn hazard measurement**, *IEEE Trans. Bio-Med. Eng.* **BME-21**, No. 5, 425-427 (Sept. 1974).

Key words: burn-hazard; heat-flow; thermal-inertia; thermesthesiometer.



Surface temperature measurement alone is insufficient to establish the hazard to the human of contact with a hot or cold object. A metal surface is more likely to cause thermal injury than a plastic surface at the same temperature. An instrument equipped with a measuring probe has been developed for indicating the temperature that would be experienced if human contact were made with the hot surface in question. The correct value of interface contact temperature can be read for a selected contact time without knowing the composition or temperature of the heated material under test.

**14590.** Crandall, D. H., Dunn, G. H., Gallagher, A., Hummer, D. G., Kunasz, C. V., Leep, D., Taylor, P. O., **Rate coefficients for electron excitation of the first resonance transition in H, Li, Na, Ca, Ca<sup>+</sup>, and Ba<sup>+</sup> calculated from experimental data**, *Astrophys. J.* **191**, No. 3, 789-793 (Aug. 1, 1974).

Key words: atomic cross sections; atomic data; atomic physics; rate coefficients; resonance lines.

By fitting cubic spines augmented with special functional forms for low and high energies to cross-section data determined experimentally at discrete values of the electron energy, we obtain an interpolation that can be visually inspected and adjusted to prevent the appearance of spurious features. The familiar integral expressing the rate coefficient in terms of the cross-sections can then be evaluated with no further approximation. This procedure is applied here to cross-section data for the first resonance transition of H, Li, Na, Ca, Ca<sup>+</sup>, and Ba<sup>+</sup>. The resulting collisional de-excitation rate coefficient, from which the excitation-rate coefficient can be determined by the detailed balance relation, is tabulated in each case for electron temperatures in the interval from 10<sup>3</sup> to 10<sup>5</sup> K and is expressed in terms of a Chebyshev expansion valid for this range of temperature.

**14591.** Pilsworth, M. N., Jr., Hoge, H. J., Robinson, H. E., **The thermal conductivity of natural rubber from 134 to 314 K**, *J. Mater.* **7**, No. 4, 580-585 (Dec. 1972).

Key words: glass transition; heat transfer; Hevea rubber; thermal conductivity; thermophysical properties; transport properties.

The thermal conductivity of soft natural rubber, compounded and vulcanized as specified in ASTM recipe 2A, has been measured over a range extending from well below the glass transition to above room temperature. The glass-transition temperature deduced from the thermal-conductivity measurements is 212 K (− 78 F). Most of the measurements were made at the Natick Laboratories in a guarded-hot-plate apparatus, with silicone rubber pads on either side of the sample. The rest of the measurements were made at the National Bureau of Standards with apparatus and procedures that have been used for many years in reference-standard work. The thermal-conductivity data are believed to be accurate to 3 percent or better at room temperature and to about 6 percent at the glass transition and below.

**14592.** Willis, P. M., Fox, M. R., **Computers for the inexperienced and impecunious**, *Liberal Education* **55**, No. 4, 545-550 (Dec. 1969).

Key words: computer science; computers; Hood College; research tool; time sharing; undergraduate education.

Hood College, a small liberal arts college in Frederick, Md., collaborated with the National Bureau of Standards in Gaithersburg in developing a work-study program in computing science that has served to introduce students and faculty to the capabilities and limitations of the digital computer. The program, sponsored by the National Science Foundation, resulted in four small liberal arts colleges establishing a computer appreciation course at nominal cost that has wide applicability to similar colleges which have access to and assistance in instruction from nearby government or industrial laboratories with computer capability.

Details of the experiment along with costs are provided in sequence for the two years it encompassed.

**14593.** Trechsel, H. R., **Structural performance testing of windows, curtain walls, and doors**, *Amer. Soc. Test. Mater. ASTM Spec. Tech. Publ.* **552**, pp. 36-41 (1974).

Key words: curtain walls; doors; test; walls; wind loads; windows.

This paper is a commentary on the ASTM Test for Structural Performance of Exterior Windows, Curtain Walls, and Doors under the Influence of Wind Loads, Designation E 330-70. A brief historical background of the development of the test method is given, the procedure is summarized, some of its features are highlighted, and the use, application, and significance of the method are discussed.

**14594.** McDonald, D. G., Risley, A. S., Cupp, J. D., **The relationship of Josephson junctions to a unified standard of length and time**, (Proc. 13th Int. Conf. on Low Temperature Physics, Boulder, Colo., Aug. 21-25, 1972), Paper in *Low Temperature Physics LT 13*, K. D. Timmerhaus, W. J. O Sullivan, and E. F. Hammel, Eds., **4**, 542-549 (Plenum Press, New York, N.Y. 1974).

Key words: cryogenics; infrared; Josephson junctions; lasers; superconductivity.

Recent developments have led to large improvements in the frequency stability of infrared lasers. The stability is now comparable with that of the primary frequency standard and greatly exceeds that of the length standard. Thus a stabilized infrared laser could become a unified standard of time (or frequency) and length and replace the two existing standards. A practical problem is that infrared frequency synthesis must be simplified and Josephson junctions show promise for this purpose.

**14595.** Siegwirth, J. D., Radebaugh, R., **The Kapitza resistance between Cu(Cr) and <sup>4</sup>He(<sup>3</sup>He) solutions and applications to heat exchangers**, (Proc. 13th Int. Conf. on Low Temperature Physics, Boulder, Colo., Aug. 21-25, 1972), Paper in *Low Temperature Physics LT 13*, K. D. Timmerhaus, W. J. O'Sullivan, and E. F. Hammel, Eds., **1**, 398-400 (Plenum Press, New York, N.Y., 1974).

Key words: alloy; copper; dilution refrigerator; Kapitza resistance.

The Kapitza resistance of work hardened copper has been found to be as much as ten times lower than that of annealed copper below 0.1 K. There are other hardening techniques which can be used for copper, such as oxygen annealing of copper containing small amounts of such impurities as Al, Be or Si or precipitation hardening of copper containing small amounts of Cr or Zr. We have measured the Kapitza resistance between a precipitation hardened alloy of Cu — 0.6 atomic percent Cr and the dilute He<sup>3</sup> stream in a dilution refrigerator. With the proper heat treatment, Cu(Cr) has a Kapitza resistance ten times smaller than annealed OFHC copper. The thermal conductivity of Cu(Cr) is about 0.1 that of OFHC copper. This is sufficient for use in heat exchangers in dilution refrigerators. Such an exchanger may be fabricated by sintering in H<sub>2</sub> at ~ 750 °C, then heat treating at ~ 450 °C to obtain low Kapitza resistances.

**14596.** Wall, L. A., **Condensed phase combustion chemistry**, *Fire Res. Abstr. Rev.* **13**, 204-219 (1971).

Key words: burning of polymers; combustion; ignition; polymer decomposition; pyrolytic decomposition.

The role of the chemical pyrolytic decomposition mechanisms of polymer decomposition in the ignition, combustion and burning of polymers is outlined in the light of available information. The particular aspects discussed are: mechanism, effect of con-



ditions, catalytic effects, energetics, types of decompositions induced and oxidative degradation, burning of polymers, heats of gasification and regression rates.

**14597.** Mahajan, B. M., **Safety standards for home playground equipment**, *Proc. 27th Annual Conf. for Engineering in Medicine and Biology, Philadelphia, Pa., Oct. 6-10, 1974*, **16**, 503 (Alliance for Engineering in Medicine and Biology, Chevy Chase, Md., Oct. 1974).

Key words: component; criteria; development; equipment; hazard; hazardousness; home playground; identification; mishap; misuse; product defect; safety standards; swing set; test method.

Summaries of swing set related accident investigations were examined in order to identify the hazards associated with swing sets. Approximately half of the swing set related mishaps were directly attributed to the design and construction defects of the products. The other half of the recorded mishaps results from improper installation, deterioration or misuse of the product.

Some necessary information, such as anthropometric data, injury threshold data, loading conditions representing child-hazard interactions, and loads applied to certain components to swing sets is presented.

Quality criteria and test methods are suggested, to establish safety standards for reducing hazards due to design and construction defects of the equipment.

**14598.** Mahajan, B. M., **Standards for athletic helmets—a state-of-the-art**, *Proc. 27th Annual Conf. for Engineering in Medicine and Biology, Philadelphia, Pa., Oct. 6-10, 1974*, **16**, 181 (Alliance for Engineering in Medicine and Biology, Chevy Chase, Md., Oct. 1974).

Key words: athletic helmets; head injury; injury criteria; safety standards.

The available information on the types of impact induced head injuries, their relative severity, and injury threshold values was collected from the literature. The search revealed that the threshold values are either questionable or are not available.

The literature search revealed that the information regarding the impact conditions which are generated by athletic mishaps is almost non-existent.

A review of standards for helmets revealed that there are no satisfactory performance standards for athletic helmets and that the performance criteria and testing procedures used to evaluate other helmets may be neither appropriate nor adequate for testing athletic helmets.

**14599.** Klein, G. P., Hamilton, C. A., **Measure power with a calculator chip and a DPM. By direct multiplication of current and voltage, you can cover a dynamic range of almost seven decades**, *Electron. Des.* **21**, 112-114 (Oct. 11, 1974).

Key words: calculator chip; digital panel meter; laser power.

This paper discusses techniques used in developing a direct reading laser power meter. Minimum modifications to a digital panel meter and the proper interfacing with a decimal arithmetic processor make this task possible. Actual working models of this device along with the power detectors are presently in use within NBS.

**14600.** Frederick, N. V., Stanley, W. D., Zimmerman, J. E., Dinger, R. J., **An application of superconducting quantum interference magnetometers to geophysical prospecting**, *IEEE Trans. Geosci. Electron.* **GE-12**, No. 3, 102-103 (July 1974).

Key words: geophysical prospecting; magnetometer; magnetotelluric; quantum interference; SQUID; superconductor.

Magnetotelluric field measurements were carried out at two geothermally interesting locations with two Superconducting QUantum Interference Device (SQUID) magnetometers. The tests demonstrated the very attractive combination of characteristics of these instruments for geophysical magnetic measurements. They have noise levels down to  $10^{-14}$  T/Hz<sup>1/2</sup> ( $10^{-5}$  gamma Hz<sup>-1/2</sup>); frequency response from 0 to several kHz; dynamic range of at least 160 dB; and in addition are portable and easy to set up in the field.

**14601.** Harrison, C. A., **Utilization of cation-selective membranes in the study of caries formation**, *J. Dent. Res.* **53**, Suppl. to No. 5, 1023-1032 (1974).

Key words: activity; calcium hydroxide; dental caries; mechanism; permselective membrane.

A caries mechanism was tested in a model experiment in which cation-permselective membranes were used to simulate the outer enamel-plaque layer. According to this theory, preferential diffusion of Ca<sup>2+</sup> and H<sup>+</sup> accelerates caries formation. The results support the theory and confirm that activity of Ca(OH)<sub>2</sub> is of fundamental importance.

**14602.** Taylor, B. N., **Cryogenic metrology**, (Proc. 13th Int. Conf. on Low Temperature Physics, Boulder, Colo., Aug. 21-25, 1972), Paper in *Low Temperature Physics LT 13*, **4**, 465-482 (Plenum Press, New York, N. Y., 1974).

Key words: cryogenics; fundamental constants; instrumentation; metrology.

The application of cryogenic technology and phenomena to selected areas of metrology is discussed. While the several and varied uses of the Josephson effects in the solution of metrological problems is the main topic reviewed, some past and present metrological uses of non-Josephson related low temperature phenomena are included. Prognostications regarding the future of the field are also given.

**14603.** Yeh, K-N., Birky, M. M., Huggett, C., **Calorimetric study of flammable fabrics. II. Analysis of flame retardant-treated cotton**, *J. Appl. Polym. Sci.* **17**, 255-268 (1973).

Key words: calorimetric; cellulose; flammability; flame retardant; heat; phosphorus; rate.

Efficiencies of three flame retardants for cellulose; phosphoric acid, diammonium phosphate and THPOH ammonia finish, have been evaluated based on the heat-release value and the rate of heat-release of treated fabrics burning in air measured with the isoperibol calorimeter. The results were compared and correlated with those obtained previously with the bomb calorimetric technique. Complete heat balances were obtained for the systems studied by correlation of the calorimetric data and the measurement of combustible gases evolved from the fabric burning in air. The rate of heat-release was found to correlate with 45° flame propagation rate. The results from the heat, rate and combustible gas measurements were interpretable in terms of existing mechanisms of flame retardant action.

**14604.** Harrison, J. O., Jr., **New information processing standards**, (Proc. of the American Association of State Highway Officials Committee on Electronics National Conf., Seattle, Washington, May 6-7, 1969), Paper in *Committee on Electronics*, pp. 23-35 (1969).

Key words: Cobol; computers; information interchange; information processing; standards.

Information processing standards are needed for the interchange of machine sensible data, the interchange of computer programs, the interchange of computer components and devices, and the interchange of computer related ideas among people. Organizations for the development of such standards exist at four



levels: international, national, Federal Government, and State Government. Two important standards recently adopted are the United States of America Standard Code for Information Interchange and United States of America Standard COBOL. Federal information processing standards are promulgated through the Federal Information Processing Standards Register.

- 14605.** Wilson, W. K., Parks, E. J., **Research program on stability of records at the National Bureau of Standards**, (Proc. 22nd TAPPI Testing Conference, Savannah, Ga., Oct. 7, 1971), *TAPPI* 55, No. 1, 151-161 (1972).

Key words: accelerated aging; dry breaking load; paper; pH; records; reflectance; specifications; stability; wet breaking load.

An outline is given of historical origins and the current status of research into records preservation at the National Bureau of Standards. The principal effort concerns causes of the degradation of paper in storage. As many compositional and environmental variables contribute to the degradation of paper, it is not practical to analyze every potential variable. Some representative data are given from which it is concluded that (1) aging processes in dry and humid gases are mechanistically different; (2) increases in acidity are concurrent with decreases in the dry breaking load of paper, but not *functionally* related; (3) blue reflectance decreases as acidity increases and the dry breaking load decreases; (4) thermal analysis may be a crude but useful tool for detecting impermanence in paper. While an interim specification for permanence may be based on pH, it appears that an accelerated aging test must eventually be specified. The validity of dry oven aging is questionable.

- 14606.** Thurber, W. R., Bullis, W. M., **Resistivity and carrier lifetime in gold-doped silicon**, *Air Force Cambridge Research Laboratories Report AFCRL-72-0076*, 37 pages (Air Force Cambridge Research Laboratories, Air Force Systems Command, U.S. Air Force, Bedford, Mass. 01730, Jan. 31, 1972).

Key words: carrier lifetime; gallium arsenide; gold-doped silicon; resistivity; silicon; surface photovoltage.

This report describes the present status of an on-going study of the properties of gold-doped silicon. Resistivity, Hall effect, and carrier lifetime are being measured at room temperature in silicon wafers doped with varying amounts of gold and either phosphorus or boron. Reasons are being sought for the apparent discrepancy between total and electrically active gold, for the discrepancy between calculated and observed resistivity in both *n*-type and *p*-type specimens with very large gold concentration, and for the diversity in capture cross-section data reported in the literature. Although many questions still remain, progress has been made in resolving these discrepancies. There is considerable evidence that the low resistivity observed at large gold concentrations is associated with the introduction of shallow acceptor states in concentrations strongly dependent on the gold concentration. The origin of these states is being sought. Initial studies of the application of the surface photovoltage method to the measurement of carrier lifetime in gold-doped silicon have been completed. This method also appears to be suitable for use on gallium arsenide specimens. A bibliography of the literature on properties of gold-doped silicon that contains 136 entries is also included as an appendix.

- 14607.** Waksman, D., Ferguson, J. B., **Fire tests of building interior covering systems**, *Fire Technol.* 10, No. 3, 211-220 (Aug. 1974).

Key words: fire hazard properties; gaseous combustion products; interior covering systems; interior finishes; smoke generation; surface flammability.

The fire performance of assemblies consisting of surface coverings applied over two types of painted substrates was in-

vestigated. Relatively noncombustible asbestos cement board (ACB) and painted plywood intended to represent a combustible substrate were used. Properties measured included surface flammability, and smoke density and gaseous combustion product levels. Considerable substrate dependence was found for these properties. On the basis of the results observed in this study, it is concluded that it would be advantageous to base fire safety ratings on the results of tests conducted on coverings applied to both combustible and noncombustible substrates.

- 14608.** Huebner, R. H., Celotta, R. J., Mielczarek, S. R., Kuyatt, C. E., **Oscillator strength values derived from electron energy loss spectra of molecules**, (Proc. VIII Int. Conf. on the Physics of Electronic and Atomic Collisions, Beograd, Yugoslavia, July 16-19, 1973), Abstracts of Papers of the *VIII International Conference on the Physics of Electronic and Atomic Collisions*, B. C. Cobic and M. V. Kurepa, Eds., I 435-436 (Institute of Physics, Beograd, Yugoslavia, May 1973).

Key words: acetone; energy loss spectra; ethanol; methanol; oscillator strengths.

The method of obtaining oscillator strengths from electron energy loss data is described.

- 14609.** Swanson, N., Celotta, R. J., Kuyatt, C. E., **Resonant structure in electron impact excitation of xenon**, (Proc. VIII Int. Conf. on the Physics of Electronic and Atomic Collisions, Beograd, Yugoslavia, July 16-19, 1973), Abstracts of Papers of the *VIII International Conference on the Physics of Electronic and Atomic Collisions*, B. C. Cobic and M. V. Kurepa, Eds., I, 478-479 (Institute of Physics, Beograd, Yugoslavia, May 1973).

Key words: electron impact; uv lasers; xenon excitation functions.

Electron impact excitation functions for atomic xenon are presented.

- 14610.** Rabinow, J., **Small business R&D — to be or not to be**, *Proc. Conf. II on Survival and Growth: The Small R&D Firm*, Sept. 27-29, 1972, pp. 29-35 (Sept. 1972).

Key words: government contracts; government laboratories; in-house research; patent rights; small company R&D.

The talk concerned small R&D research firms and the difference between those who make a product and those that work strictly as consultants. I discussed the nature of government R&D contracting and the less-than-honorable practices indulged in both by the government and by contractors. The arguments of how much R&D work should be done by government in-house versus outside was touched upon and I pointed out that if the government people are to be competent they must do in-house research and the small R&D firms would do better under such conditions. The question of patent rights was also discussed.

- 14611.** Rabinow, J., **Improving the patent system**, (Proc. Conf. in American Patent Law Association's Annual Meeting, Washington, D.C., Oct. 19, 1972), *American Patent Law Association's Bull.*, pp. 608-625 (Oct.-Nov. 1972).

Key words: antitrust; Department of Justice; human inertia; innovation; inventions; patents and the courts.

The talk touched on the subject of the attacks on the patent system and the recent interest in invention and innovation at the high levels of Government. The relationship between material wealth, the quality of life and the role of the inventor were discussed. The processes of invention and innovation were compared to other games of chance and the effects of adjusting the odds were discussed. A plea was made for raising the odds for the inventor. The talk illustrated the attitude of some members of the Department of Justice and the courts relative to the inventor. The quality of patents as issued by the Patent Office was



mentioned, together with a plea to keep the quality as high as possible. The Patent Bar was also asked to improve its ethics and to eliminate the attorneys and some organizations that now are fleecing the unsophisticated inventor. The talk closed with a discussion of the difficulty of introducing an invention into the real world.

**14612.** Wyly, R. S., Orloski, M. J., **Studies of reduced-size venting of sanitary drainage systems in the USA**, (Proc. CIB Commission W62 Symp. on Gravity Drainage, Stockholm, Sweden, Sept. 24-25, 1973), Paper 13 in *Drainage Services in Buildings, D14:1973*, pp. 13:1-13:19 (National Swedish Building Research, Stockholm, Sweden, 1973).

Key words: air demand; criteria for venting; reduced-size venting; trap performance; trap-seal retention/reduction; venting criteria; venting, reduced-size.

Results of experimental studies of reduced-size venting in the USA are summarized, tentative criteria are presented, and the need for further work leading to a general method for computation of vent sizes is discussed. Experimentation with vents smaller than customarily allowed has shown satisfactory performance under selected conditions that seem representative of the service environment.

Among the significant findings were: (1) trap-seal retention was adequate with peak fluctuating suction of as much as 75 mm water column for a water closet trap, and about 38 mm for a lavatory P-trap, compared with the 25 mm presently assumed for design, (2) air demand rates required to assure adequate trap-seal retention were significantly less than presently assumed, probably because of effective "slippage" between air and water in short stacks and because of air circulation in systems comprised of a piping "network," (3) discharge profile and accumulative duration of test loading significantly affected idle trap-seal performance, and (4) back pressure (blow-back) was a significant criterion for system performance, particularly at the ground-floor elevation of a high-rise system.

**14613.** Yakowitz, H., Fiori, C. E., Newbury, D. E., **Implications of specimen current and time differentiated imaging in scanning electron microscopy**, (Proc. Sixth Annual Scanning Electron Microscopy Symp., Chicago, Ill., Apr. 21-23, 1973), Chapter in *Scanning Electron Microscopy/1973; Part I*, pp. 173-180 (IIT Research Institute, Chicago, Ill., Apr. 1973).

Key words: channelling patterns; iron; lunar samples; magnetic contrast; scanning electron microscope; signal differentiation; specimen current images.

The technique of specimen current imaging has not been widely used in the SEM field, primarily because of a lack of an adequate amplifier system to operate with the low beam current, typically  $5 \times 10^{-11}$  amperes, used in high resolution work. A current amplifier capable of providing images of the specimen current signal when that signal is as low as  $5 \times 10^{-12}$  amperes is described briefly. This instrument also provides differentiation with respect to time (time differentiation) of either the absorbed current or secondary electron signals from the specimen.

Micrographs comparing the secondary electron and specimen current images under various operating conditions are discussed in terms of picture quality. Often, the specimen current image provides information which cannot be obtained from the emissive mode (primary or secondary electrons) image or else is especially difficult to obtain because of specimen/collector geometry. In the past, direct current amplifiers were unable to operate with sufficiently low specimen currents for high resolution photography. Therefore, the impression that specimen current imaging was intrinsically inferior to secondary electron imaging was promulgated. The use of present day equipment indicates that this impression is not correct.

The extra flexibility added by a time differentiating device for both the secondary electron and specimen current modes is described. Mixing the normal signal with the time differentiated signal in all proportions is desirable in order to retain some field depth while reducing gray level disparity.

**14614.** Henderson, M. M., **Programs and services of the Federal Library Committee's task force on automation**, *Proc. 1st Annual Federal Interagency Field Librarians' Workshop, Washington, D.C., Sept. 24-28, 1972*, pp. 57-68 (Sept. 1972).

Key words: automation of library operations; Federal Library Committee; field libraries; FLC; library automation; task force on automation.

The Federal Library Committee's Task Force on Automation (TFA) has established a program which will contribute to effective and efficient improvement of Federal library and information services. The program is based on data collected during a recent survey of the Federal library community, for which the TFA served in a technical advisory capacity. Priorities include development of a tutorial workshop on techniques of evaluation for library automation, establishment of a reference file on current Federal library automation activities, and participation in a study of the feasibility of a Federal library service center operation. Such programs are of interest, and will prove of benefit, to field libraries within the Federal establishment.

**14615.** Wiese, W. L., McClelland, J. F., Kelleher, D. E., Paquette, D. R., **Continuous emission from hydrogen plasmas. II. Experimental studies with a wall-stabilized arc**, *Proc. 9th Int. Conf. on Phenomena in Ionized Gases, Bucharest, Romania*, p. 596 (Sept. 1969).

Key words: continuum; emission intensity; hydrogen; plasma.

A wall-stabilized arc operating in hydrogen is used for the measurement of the continuous hydrogen emission in the visible and near ultraviolet regions of the spectrum. The arc plasma is spectroscopically analyzed, and measured continuum intensities are compared with recent extensive calculated values. Consistency is observed at all measured wavelengths.

**14616.** Blackburn, D. L., Oettinger, F. F., **Transient thermal response measurements of power transistors**, *Proc. IEEE Power Electronics Specialists Conf., Bell Telephone Laboratories, Murray Hill, N.J., June 10-12, 1974, PESC '74 Record*, pp. 140-148 (IEEE, New York, N.Y., Oct. 1, 1974).

Key words: computer simulation (transient thermal); current crowding (transistors); power transistors; thermal impedance measurements; thermal response measurements; transistors (thermal measurements).

Differences between the measured thermal impedance of power transistors when determined by the pulsed heating curve and cooling curve techniques are discussed. These differences are shown to result primarily because the power density distributions of these devices change as the devices heat; as a result of these changes the heating curve and the cooling curve are not conjugate. It is shown that the cooling curve technique, when the cooling curve is initiated from the most non-uniform steady state thermal distribution, (maximum voltage, maximum power) will indicate a larger value for the thermal impedance than will the pulsed heating curve technique, even for pulses in excess of the d-c power level. A one dimensional model for power transistor cooling is described. The theoretical predictions of the model are shown to be in good agreement for practical applications with three-dimensional computer simulations and experimental results. Using this model, it is possible to estimate an average junction temperature and the area of power generation at steady state. Both TO-66 and TO-3 encased devices of mesa and planar structures were included in this study.



**14617.** Brauer, G. M., Termini, D. J., **Grafting of monomers to collagen and hard and soft tissues**, (Proc. XXIII International Congress of Pure and Applied Chemistry, Boston, Mass., July 1971), *Macromolecular Preprint* **1**, pp. 601-608 (1971).

Key words: collagen; graft polymers; hard tissue; soft tissue; surface grafting; tissue modification.

Grafting of monomers to collagenous surfaces offers an attractive technique for modifying the surface properties of soft and hard tissues. Some 20 monomers were grafted to purified steel-hide collagen powders or films using  $1.10^{-3}$ M ceric ammonium nitrate as initiator. Yields after extraction of homopolymer were greatly dependent on the monomer used. With the most reactive monomers, surface grafts were obtained within 15 minutes. The large variety of monomers, including those with additional reactive or crosslinking groups, graftable to collagen indicates that surfaces with the desired hydrophilichydrophobic balance to fit specific applications can be obtained. Some monomers such as ethylene dimethacrylate or glycidyl methacrylate could be grafted to epidermal calfskin. No apparent grafting to calfskin was observed for most of the other monomers. Apparently, the presence of the keratinous layer reduces the reactivity toward graft polymerization. On grafting glycidyl-, dimethylaminoethyl-, isobutyl methacrylate or 1,3-butylene dimethacrylate to powdered bone, an increase in weight of from 11 percent to 60 percent after acetone and chloroform extraction was obtained. Dentin surfaces are not as susceptible to grafting as powdered bone. The relative grafting efficiency of monomers to the solid substrate decreases in the following order: collagen powder, collagen film, bone powder, epidermal calfskin, ratskin, dentin powder.

**14618.** Loevinger, R., **Some remarks on the MIRD Schema for absorbed-dose calculations for biologically-distributed radionuclides**, (Proc. Symp. on Medical Radionuclides: Radiation Dose and Effects, Oak Ridge, Tenn., Dec. 8-11, 1969), Chapter in *Medical Radionuclides: Radiation Dose and Effects*, R. J. Cloutier, C. L. Edwards, W. S. Snyder, Eds., pp. 481-489 (Available as CONF-691212 from the National Technical Information Service, Springfield, Va. 22161, June 1970).

Key words: dosimetry, radionuclide; internal dose calculation; nuclear medicine; radionuclide dosimetry; reciprocity relationship; specific absorbed fraction.

The origin of the MIRD Schema [*Journal of Nuclear Medicine*, Supplement No. 1 (February 1968)] is described. The basic concepts, equations, and advantages are discussed and explained. The concept of specific absorbed fraction allows formulation of a single equation that covers internal-dose calculations for all radiations, sources and targets.

**14619.** Ausloos, P., Lias, S. G., **Far ultraviolet photochemistry of organic compounds**, *Proc. NATO Advance Study Institute on Chemical Spectroscopy and Photochemistry in the Vacuum Ultraviolet*, Valmorin, Quebec, Canada, Aug. 5-17, 1973, pp. 465-482 (Aug. 1973).

Key words: far ultraviolet photochemistry; free radicals; organic compounds; photofragments; primary processes; quantum yield.

A brief survey is presented concerning certain aspects of the far ultraviolet photochemistry of organic compounds. The use of spectroscopic methods and chemical analysis of final photolytic products are discussed as methods of obtaining information about the fates—particularly the modes of decomposition—of compounds excited by absorption of photons having energies above about 8 eV. Commonly used photolytic light sources which deliver photons in the energy range 7.6 eV-21.2 eV are described.

Generalizations which can be drawn concerning the primary modes of decomposition of excited alkanes, cycloalkanes, and carbonyl compounds in this energy range are discussed.

**14620.** Somes, N. F., **Experience with the development and application of structural performance criteria**, (Proc. Workshop on Systems Building, NBS, Gaithersburg, Md., Feb. 24-26, 1972), Paper in *Systems Building*, pp. 269-292 (Available from the National Technical Information Service, Springfield, Va. 22161, 1972).

Key words: building; evaluation; performance criteria; physical simulation; structural safety; structural serviceability.

The paper is based upon experience gained by the author as a member of the NBS team which over the past two years has served as the technical arm of HUD in Operation BREAKTHROUGH. A brief introduction to the nature of BREAKTHROUGH is followed by a description of the task of preparing the Guide Criteria. The housing system producers within the program were required to submit evaluation documents. These are described together with the experience of the evaluation team in dealing with these documents. Recommendations are given as to the ways in which future evaluations might avoid difficulties and time delays. When it is not possible to evaluate through this submission of documents it may be necessary to use physical simulation. To illustrate this technique a case history is presented of the evaluation of the system which used concrete box modules.

**14621.** Utech, H. P., **Status report on research programs for firefighters protective clothing**, *Proc. Fire Department Instructors' Conf., Kansas City, Mo., Mar. 27-30, 1973*, pp. 156-166 (1973).

Key words: comfort; fire coat; firefighting; impact protection; injury statistics; protective clothing; thermal conditions; turnout coat.

The inadequate design of present-day protective clothing and equipment used by firefighters can be attributed to a lack of quantitative data on what that equipment is expected to do and under what conditions it must perform. Research on firefighters' turnout gear at the National Bureau of Standards has focused on developing the needed quantitative data. Progress in defining the hazards faced by firefighters, measuring the performance of present-day coats, quantifying the thermal conditions to which firefighters are exposed, predicting the performance of protective equipment under those conditions, and using this information to specify the design of improved turnout gear is described.

**14622.** Taylor, J. K., Zielinski, W. L., Jr., Maienthal, E. J., Durst, R. A., Burke, R. W., **Development of method for NTA analysis in raw water**, *U.S. Environmental Protection Agency EPA Report R2-72-057*, 34 pages (Sept. 1972).

Key words: chemical analysis; nitriolotriacetic acid; NTA; water analysis; water pollution.

The free acid form of nitriolotriacetic acid is readily esterified by N,O-bis(trimethylsilyl)acetamide and gas chromatographic analysis is directly applicable to this derivative. The response characteristic of NTA-trisilylester was 2,200 mm<sup>2</sup> peak area per microgram of NTA at maximum sensitivity of the hydrogen flame ionization detector. Accordingly, gas chromatography has the potential for detecting NTA concentrations of practical interest providing that suitable NTA isolation techniques can be developed.

The cupric ion-selective electrode provides the basis for a sensitive electrochemical detector for NTA. Apparatus for the on-stream determination of uncomplexed NTA has been developed. This may be used for determination of total NTA, after the latter



is separated from bound metal ions and other complexing agents by a suitable means, such as ion-exchange chromatography.

Polarographic studies have shown that the bismuth-NTA complex is a suitable method for the determination of NTA in most waters. While some metal ions may interfere, a pre-electrolysis step and/or a standard addition technique seems feasible to eliminate this problem.

Potentiometric titration with cupric ion should provide a rapid and reliable referee method for the determination of NTA in detergent formulations. Such a method would appear to be superior to the spectrophotometric methods presently used, since the latter are affected by turbidities which are encountered in many of the samples.

**14623.** Walker, J. C., Hughes, C. E., **POPSS—a parametric operating system simulator**, *Proc. SIGCSE Meeting, Columbus, Ohio*, pp. 166-169 (1973).

Key words: computer system; FORTRAN IV; operating system; resource allocation strategies; simulator.

In this paper we describe POPSS, an event driven simulator which is intended to simulate the activity of a computer system—hardware together with an operating system—as it processes a workload. Input to the simulator is in the form of keyword parameters which are used for describing all three components—hardware, operating system, and workload.

POPSS is a simulator as opposed to a simulation language. It is designed to model the inner workings of a computer system in addition to yielding the results usually associated with simulation. The program is highly modular, consisting of some 45 subprograms. Of these, there are 22 modules, each of which represents an operating system component (or possibly a part of one such component). Included in POPSS are built-in replacement features to allow a user the capability of designing alternative resource allocation strategies. These features are in addition to the standard subprogram replacement automatically available through the use of FORTRAN IV.

**14624.** Loevinger, R., **Absorbed dose from interstitial and intracavitary sources**, (Proc. Conf. Afterloading in Radiotherapy, New York, N.Y., May 6-8, 1971), Chapter in *Afterloading in Radiotherapy*, N. Simon, Ed., DHEW Publ. (FDA) 72-8024 BRH/DMRE 72-4, pp. 192-203 (U.S. Department of Health, Education, and Welfare, Bureau of Radiological Health, Rockville, Md. 20852, Dec. 1971).

Key words: absorbed dose; buildup factor; gamma radiation; implant; interstitial; intracavitary; point source.

A quantity of importance in the dosimetry of  $\gamma$ -ray sources is the ratio of the absorbed dose to the exposure in air at the same point. This is calculated from energy-absorption buildup factors for some  $\gamma$ -ray sources of clinical importance, and shows reasonable agreement with formulae which represent experimental determination. It is shown that penetration through tissue is adequate for implant therapy for quantum energies as low as 25 keV.

**14625.** Yakowitz, H., **A practical examination of the Kossel x-ray diffraction technique**, Chapter 11 in *Microprobe Analysis*, C. A. Andersen, Ed., pp. 383-421 (John Wiley & Sons, Inc., New York, N.Y., 1973).

Key words: crystal orientation; error propagation; Kossel lines; lattice spacings; stress-strain maps; x-ray diffraction.

The divergent beam (Kossel) x-ray diffraction method can provide lattice spacing data and crystallographic orientation information from regions 15  $\mu\text{m}$  in diameter by 2 to 10,000  $\mu\text{m}$  in depth depending on the experimental conditions and the target. A typical depth value is 50 to 75  $\mu\text{m}$ . In addition, all of the (hkl)

planes of a family are separated, i.e., if (222) appears then (2 $\bar{2}$ 2) will appear as a separate entity. This last circumstance permits a Kossel Internal Stress-Strain (KISS) analysis to be carried out in a straightforward way. In particular, the Cauchy strains, principal strains and their axes, principal stresses and their axes, maximum shear strain in any (hkl) plane and the total stored elastic energy in the irradiated region can be calculated for lightly strained materials. This paper will describe the Kossel method in general with emphasis on the KISS analysis—especially from the point of view of reliability of the KISS results. The object will be to illustrate the power of the KISS but also to point out its limitations in practice. Experimental design will be discussed in terms of its effect on the stress-strain analysis results.

**14626.** Gadzuk, J. W., **Electron spectroscopy of chemisorbed atoms**, Lecture Notes from the IXth Winter School of Theoretical Physics, Karpacz, Poland, Feb. 16-29, 1972, *The Theory of Metals and the Many-Body Problem, Acta Universitatis Wratislaviensis No. 181, II*, pp. 1-19 (1972).

Key words: chemisorption; field emission; ion neutralization; photoemission; tunneling.

The techniques of Ion Neutralization Spectroscopy, Field Emission Resonance Tunneling and Ultraviolet Photoemission as valence level probes of chemisorbed atoms are discussed.

**14627.** Harvey, D. G., Achenbach, P. R., **Opportunities for improving energy utilization in residences**, *Proc. Effective Energy Utilization Symp., Drexel Univ., Phila., Pa., June 8-9, 1972*, pp. 234-247 (1972).

Key words: appliance performance; energy conservation; energy use; heating and air conditioning; residential energy consumption.

The construction features of a typical single-family residence in the northeast region of the United States are described together with average annual energy consumption for space heating and cooling, domestic water heating, and electric appliances. The market saturation in the use of the various electrical appliances in the typical residence is summarized. The potential for energy savings in the design and use of appliances, heating, ventilating, and air conditioning systems, and the building itself is summarized with reference to cost effectiveness and acceptability to the occupant. A summary of recommended areas for research in energy conservation in residences is provided.

**14628.** Vadelund, E. A., **Change to metric can maximize package size rationalization**, *Proc. DFISA Conf., Las Vegas, Nev., Mar. 28, 1973*, pp. 45-48 (1973).

Key words: labeling; metric system; packaging; size rationalization; state and federal laws and regulations.

Presents a brief overview of the current status of metrication including legislative activities. Outlines the changes that need to be considered by the packaging industry in the event a measurement system change occurs.

**14629.** Kirsch, R. A., **Resynthesis of biological images from tree-structured decomposition data**, (Proc. Int. Federation on Information Processing, Vancouver, British Columbia, May 22-26, 1972), Chapter in *Graphic Languages*, F. Nake and A. Rosenfeld, Eds., pp. 1-19 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1972).

Key words: biomedical; image processing; pattern recognition.

In this paper we are simultaneously concerned with methods for decomposing grey scale microscope images and with methods for verifying the correctness of these decompositions. One such method is resynthesis. Resynthesis is viewed as a procedure whereby an analyzed scene can be reconstituted and



subjected to an analysis by human (informal) methods to determine the information preservation of the process. Several algorithms are presented for different ways of resynthesizing a decomposed image from its morphological decomposition analysis.

- 14630.** Hill, J. E., Kusuda, T., Powell, F. J., **A concept for determining the need for air conditioning**, (Proc. ASHRAE Symp. for Air Conditioning Criteria for Man's Living Environment, Louisville, Ky., June 24-28, 1973), *ASHRAE Bull.* LO-73-8, pp. 14-17 (1973).

Key words: air conditioning criteria; comfort indices; human comfort.

Previously written criteria that govern the decision to install or not to install air conditioning, have been based solely on the climate. This paper proposes the need for a criteria with a sounder technical base together with the manner in which it can be established. Detailed building data and hour by hour weather data are combined in a precise thermal simulation to predict the hour by hour indoor conditions that would exist (dry-bulb temperature, wet-bulb temperature, and mean radiant temperature). The conditions are in turn compared to the accepted comfort standards (ET\*, Kansas State University Index, Predicted Mean Vote, etc.) in order to ascertain whether air conditioning is required.

The paper gives the details of a comprehensive study showing the feasibility of such a scheme. A thermal simulation was made on an apartment building located in Jersey City, New Jersey, using the weather data of ten consecutive summers. The simulation results revealed the extent and duration of undesirable indoor conditions when this apartment is not air-conditioned. The magnitude of computational effort appears formidable if detailed simulation calculations are to be carried out for the many combinations of buildings and climatic zones in the United States. Therefore, an attempt was made to obtain statistical correlations between the indoor and outdoor conditions for this apartment. The attempt was reasonably successful and a short-cut technique for establishing criteria is indicated.

- 14631.** Frommer, M. A., Shporer, M., **The properties of water in polymeric membranes. I. Freezing and non-freezing water in cellulose acetate membranes**, *Proc. Am. Chem. Soc. 163rd Meeting on Organic Coatings and Plastics Chemistry Symp.*, Boston, Mass., **32**, No. 1, 374-381 (Apr. 1972).

Key words: cellulose acetate membranes; differential scanning calorimetry; freezing in porous systems; membranes; NMR relaxation times; nuclear magnetic resonance.

The relative amounts of freezing and non-freezing water in various water-wet cellulose acetate (CA) membranes have been determined by differential scanning calorimetry (DSC) and by nuclear magnetic resonance (NMR) techniques. DSC results suggest that: 1) A significant fraction (17-40%) of the water (1.0-3.1g H<sub>2</sub>O per g dry CA) in any membrane does not freeze at temperatures as low as -60 °C; 2) The amount of non-freezing bound water (0.40-0.7g non-freezing water per g dry CA) depends upon the nature of the membrane, and is significantly higher than the total amount of water (all of which is non-freezing) absorbed from liquid water by a dense film of the same polymer (~0.18g water per g dry CA). The structures of the membranes studied by scanning electron microscopy suggest that the amounts of non-freezing water in cellulose acetate membranes decrease with the increase in the packing density (compactness) of the polymer within the membrane. NMR data suggest that: 3) The non-freezing water is highly mobile compared with ice. 4) The relative amounts of non-freezing water computed from NMR experiments are comparable to those estimated from DSC measurements. 5) All the water contained in

membranes equilibrated with water vapors are bound to the polymer and do not freeze.

- 14632.** Wall, L. A., Roestamsjah, Aldridge, M. H., **Pyrolysis of mixtures of monodisperse poly  $\alpha$ -methylstyrenes**, *Amer. Chem. Soc. Polymer Preprints* **13**, No. 2, 1041-1043 (Aug. 1972).

Key words: polymers; pyrolysis; poly  $\alpha$ -methylstyrene, zip-length.

Mixtures of monodisperse poly  $\alpha$ -methylstyrenes were pyrolyzed and their rate of weight lost measured as a function of molecular weight. The pyrolytic weight lost of poly  $\alpha$ -trideuteromethyl  $\beta$ ,  $\beta$  dideuterostyrenes were also studied. This polymer gives pure monomer as a volatile product and has a large zip-length. For very large zip-length compared to molecular weight, theory predicts a rate proportional to weight average degree of polymerization. We observed a dependence in excess of the weight average D, P. in the region that the rate is approximately proportional to molecular weight. This is suggestive of an effect related to the physical properties of the liquid melt in the direction to increase the zip-length.

The present results on monodisperse polymers indicate longer zip-lengths than previously estimated from measurement on fractionated poly  $\alpha$ -methylstyrenes. Also the monodisperse deuterated polymers have an even longer zip-length compared to the nondeuterated polymers.

- 14633.** Simiu, E., **Improved methods for determining wind profiles and dynamic structural response to wind**, *Proc. ASCE-IABSE Regional Conf. on Tall Buildings, Bangkok, Thailand, Jan. 1974*, pp. 491-503 (1974).

Key words: aerodynamics; dynamic response; gust factor; structural engineering; wind profiles; wind spectra.

In current methods for determining alongwind structural response, it is assumed that wind profiles are described by empirical power laws and that turbulence spectra are independent of height. In this paper, the adequacy of these assumptions is assessed in the light of recently established results of boundary layer meteorology. An improved method for determining wind profiles is presented, and expressions for the dynamic alongwind response, including deflections and accelerations, are proposed. In addition to the variation of wind spectra with height, these expressions take into account the pressure correlations in the alongwind direction, determined in accordance with basic theory and known experimental results.

- 14634.** Renninger, C. R., **Central government structure for the development of an ADP policy**, *Proc. 7th Conf. Intergovernmental Council for ADP, Ottawa, Canada, Sept. 17-19, 1973*, pp. 57-71 (1973).

Key words: ADP policies; computer technology; management; quality control; software.

Advancements in computer technology, the emergence of computer subindustries with new products and marketing strategies, and the growing maturity of both the computer supplier and the computer user are forcing a reexamination of governmental ADP policies. A dominant issue is the management of computer software which has become the critical factor in achieving effective use of computer technology as well as the most expensive element of computer operations. The level of computer effectiveness can be increased significantly by improving software. Better quality control over the production of software is needed to eliminate errors and provide guarantees of satisfactory performance. The utility of proven software needs to be extended to other users to avoid redundant and costly developmental efforts. Ways must be found to reduce the time required to produce software and thereby bring operational systems on-stream sooner.



Specific actions taken by the National Bureau of Standards, General Services Administration, and the Office of Management and Budget to improve software management in these areas of need are described.

- 14635.** Young, R. H., Brewer, D., Kayser, R., Martin, R., Feriozi, D., Keller, R. A., **On the mechanism of quenching by amines: A new method for investigation of interactions with triplet states**, *Can. J. Chem.* **52**, No. 16, 2889-2893 (1974).

Key words: lasers; photochemistry;  $^1\Delta O_2$ .

Rate constants for the quenching of singlet oxygen by a series of substituted *N,N*-dimethylanilines were obtained by a direct method employing dye-laser. The Hammett  $\rho$  value obtained from the data ( $-1.71$ ) suggests that a (partial) charge-transfer complex may be responsible for the quenching action. This rate data was combined with that obtained for the total quenching action on the sensitized photooxidation of 1,3-diphenylfuran. The quenching action on the photooxidation reaction is due to both the quenching of singlet oxygen and the quenching of the triplet state of the sensitizer (rose bengal or methylene blue). The combination of the data from each series of experiments resulted in rate constants of quenching of the triplet states of the sensitizers. A number of the *N,N*-dimethylanilines quenches the triplet states at the diffusion limit. Hammett  $\rho$  values ( $-1.86$  for rose bengal and  $-4.19$  for methylene blue) indicate that charge-transfer intermediates are probably responsible for the quenching action. This was confirmed by the observation of a transient intermediate assigned to the charge-transfer radical of methylene blue. The technique used here represents a novel approach to the investigation of triplet states.

- 14636.** Madden, R. P., **Synchrotron radiation and applications**, Chapter 7 in *X-ray Spectroscopy*, L. Azaroff, Ed., pp. 338-378 (McGraw-Hill Book Co., New York, N.Y., 1974).

Key words: radiation; source and electrons; synchrotron; x-ray, vacuum ultraviolet.

The historical development of the theoretical understanding of synchrotron radiation is reviewed. The important equations necessary to calculate the details of the angular, polarization and wavelength distribution of the radiation and the dependence of these properties on the electron energy and the radius of the trajectory are presented. Also approximate expressions are given which can be utilized to quickly estimate these properties for any given source of synchrotron radiation. The observational development of synchrotron radiation is also historically reviewed, presenting the experimental verification of the theoretical predictions and including a short history of the world's major synchrotron radiation laboratories. Finally, applications of synchrotron radiation in experimental physics are presented, including examples where important contributions have resulted in areas of atomic, molecular, solid state and surface physics as well as in radiometry.

- 14637.** Thomas, D. B., Freeze, P. D., **The effects of catalysis in measuring the temperature of incompletely-burned gases with noble-metal thermocouples**, *Proc. 5th Symp. Temperature—Its Measurement and Control in Science*, Washington, D.C., June 21-24, 1971, pp. 1671-1676 (1971).

Key words: butane; carbon monoxide; catalysis; combustion; hydrogen; optical pyrometer; platinum; platinum-13 percent rhodium; temperature; thermocouple.

Measurements have been made on the effects of catalysis when platinum-13 percent rhodium versus platinum thermocouples are used to measure the temperature of incompletely-burned gases in the temperature range 1000 to 1500 °C. These measurements indicate that significant temperature errors can result when noble-metal thermocouple materials are exposed to various unburned gases under laboratory test conditions. Platinum

and platinum-13 percent rhodium thermocouple elements were exposed to gas mixtures of air + 1.0 percent  $H_2$ , air + 2.0 percent  $H_2$ , air + 1.0 percent CO + 0.01 percent  $H_2$ , air + 2.0 percent CO + 0.01 percent  $H_2$  and air + 0.5 percent  $C_4H_{10}$ . At very low gas velocities ( $< 9 \times 10^{-3}$  m/second), the thermoelement temperature increase due to surface combustion varied from about 2 to 77 °C at thermoelement temperatures between 1000 and 1500 °C. At gas velocities between  $0.17 \times 10^2$  and  $1.83 \times 10^2$  m/second, the temperature increases varied between 35 and 380 °C. Measurements with five gas mixtures indicate that the sample temperature increases ( $\Delta T$ ) due to catalytic heating increase with increasing gas velocity up to approximately  $1.2 \times 10^2$  m/second. Above  $1.2 \times 10^2$  m/second, the  $\Delta T$  values tend to decrease with further increasing velocity.

- 14638.** Marton, L. L., **Article on Baron Roland von Eötvös**, *Dictionary of Scientific Biography* **4**, 377-381 (1971).

Key words: Eötvös balance; Eötvös' law of surface tension; equivalence of gravitational and inertial mass; geophysical exploration; public service; torsion balance.

Born in 1849 in Budapest, Hungary, he studied in Heidelberg and in Königsberg, Germany. Returning to Hungary he became Professor at the University of Budapest. For a few years he pursued research on surface tension, but after 1888 Eötvös devoted all his research efforts to the problem of gravitation. He designed the "Eötvös torsion balance" and used it for geophysical exploration as well as for measurements of the equivalence of gravitational and inertial mass. He served briefly in the Hungarian Cabinet as Minister of Public Worship and Education, as "Rector" of the University, as President of the Hungarian Academy of Sciences, etc. He died in 1919.

- 14639.** Simiu, E., **Variation of mean winds with height in hurricanes**, *J. Eng. Mech. Div. Am. Soc. Civil Eng. Tech. Note* **100**, No. EM4, 833-837 (Aug. 1974).

Key words: boundary layer; hurricanes; loads (forces); natural disasters; structural analysis; tall buildings; wind profiles.

The magnitude of wind pressures on buildings and structures depends, among other factors, upon the variation of wind speeds with height. The presence in hurricane flows of strong inertial forces due to the curvature of the isobars in the region of highest winds suggests that differences exist between hurricane velocity profiles and the logarithmic profiles typical of extratropical winds. Simplified models of boundary layer flow in cyclostrophic and geostrophic flow are used to show that these differences appear to be significant. The results obtained suggest that an investigation based on a more realistic model of actual atmospheric boundary layer flow is warranted. Suggestions are made for the major ingredients of an alternative model and the use of existing models for numerical solution of the model. These indicate the feasibility of getting more reliable estimates for the variation of the winds with height under hurricane conditions. The author is currently conducting research along the lines indicated.

- 14640.** Stillman, R. B., **A survey of techniques for increasing software reliability**, *Proc. Summer Computer Simulation Conf.*, Montreal, Canada, July 1973, pp. 1130-1133 (1973).

Key words: dynamic analysis; proof of correctness; software reliability; static analysis; testing software.

The quality of today's major software systems is uneven at best. Programs thought to be correct will suddenly produce wrong results, no results, or behave otherwise erratically, because some special condition in the data or in the environment was not accounted for in the logic of the program. Techniques to improve reliability and to facilitate thorough testing of software fall into two main categories: (1) Static analysis, which is performed without executing the software. Questions of overall



software system design, higher-level language design, use of various static analysis tools, and the concept and potential of machine generated proofs of correctness are addressed; (2) Dynamic analysis, which is dependent upon information collected while the software is in execution. Interest is centered on frequency (of execution) monitors; dynamic debugging facilities, address range and data bound checks, optionally compilable assertions, and tracing and tracking tools.

- 14641.** Walter, L. S., French, B. M., Heinrich, K. F. J., Lowman, P. D., Jr., Doan, A. S., Adler, I., **Mineralogical studies of Apollo 12 samples**, (Proc. Second Lunar Science Conf. Houston, Tex., Jan. 11-14, 1971), *Geochim. Cosmochim. Acta Suppl.* 2, 1, 343-358 (1971).

Key words: Apollo 12; crystallization; mineralogy; moon; petrography; pyroxene; rocks.

The five crystalline rocks studied represent three distinct chemical groups: (1) low-Mg, high-Al; (2) intermediate; and (3) low-Al, high-Mg. Petrography and mineral compositions are consistent with the suggestion that the differences reflect olivine removal during crystallization, producing Mg-rich cumulate rocks and Mg-poor residual liquids. Some mineralogical characteristics are consistent with this model. However, significant mineralogical differences are observed between specimens in the same chemical group, suggesting that the actual crystallization relations are more complex. Ni-Fe metal, possibly emplaced as a late-stage vapor deposit, occurs in cracks in pyroxene and chromite, and along pyroxene cleavage elements. The metal has the same nickel content as other metal in the sample and is not associated with sulfide. No concentration gradients in iron in the host crystal are observed.

- 14642.** Wright, J., **Integration of the performance concept into building regulation**, *Proc. 3rd South African Symp. National Building Regulations, Durban, South Africa, May 17, 1974*, pp. 20-23 (1974).

Key words: building codes; building technology; energy conservation; evaluation and acceptance system; National Bureau of Standards; National Conference of States on Building Codes and Standards; performance concept.

Building regulation is an exercise of the police power and is therefore, by authority of the United States Constitution, a function of the member States of the Federal republic. But historically building has been a local enterprise and the States left its regulation to the cities since so many regulatory issues, e.g. conflagration, dealt with circumstances of urban life. The result is a mosaic of thousands of regulatory jurisdictions. This situation imposes burdens on building technology because each jurisdiction has its own set of standards (called a code) and enforcement practices. While traditional technology has managed to cope fairly well with the multiplicity of regulations and practices, innovative technology has been less successful. Performance standards would help to offset this imbalance since they are equally accommodating of new and traditional technology. However, performance standards require a performance evaluation and acceptance system if they are to be usefully promulgated. This is a key concept with the relatively new National Conference of States on Building Codes and Standards, an organization working to improve the regulatory climate. At the request of the Conference, the National Bureau of Standards (NBS) has prepared a document called "Draft Design and Evaluation Criteria for the Conservation of Energy in Buildings." The document is based on the performance concept with which NBS has had considerable experience. The NBS effort is also addressed to institutional mechanisms, including those necessary for a performance evaluation and acceptance system. The latter is seen as a complement to—not a competitor of—the established regulatory system.

- 14643.** Wright, J. R., Herron, W. R., **Housing research at the National Bureau of Standards**, *Proc. Silver Jubilee Celebration of the Central Building Research Institute of India, Roorkee, India, Feb. 29-Mar. 2, 1973*, pp. 19-24 (1973).

Key words: building research; industrial building; performance criteria; total energy.

As the Central Building Research Institute at Roorkee is holding its Silver Jubilee, there is abroad in the world a great demand for relevance of many activities formerly left to random coordination. This is true in the United States of America and to some degree is the cry of all mankind. The Central Building Research Institute is to be commended for the achievement of relevance between the requirements of the people of India and their building research efforts. This has been accomplished by a steadfast adherence to the principle that sophisticated science can be turned to practical applications by research which recognizes the need to gear these applications into the patterns of everyday life in India. The thrust of this paper is to establish the realization that "Housing is a Social Process," since it involves a continuously changing interrelationship between national cultural goals, the designers, builders, and users. This realization is achieved to a varying degree from one culture to another. Some of the work described herein will show courses of action which can enhance the social significance of the building process.

- 14644.** Sengers, J. M. H. L., **Critical point**, *Encyclopedia Americana* 8, 219-220 (Americana Corp., New York, N.Y., 1973).

Key words: critical anomalies; critical opalescence; critical point; critical-point phase transitions.

For the general reader, the critical point is defined using the gas-liquid system as an example. Critical anomalies and light-scattering methods for studying these are discussed. Some further examples of critical-point phase transitions are enumerated and their analogy is stressed.

- 14645.** Madden, R. P., **The Frederic Ives Medal for 1971**, *J. Opt. Soc. Amer.* 62, No. 8, 927-930 (Aug. 1972).

Key words: Ives, medal; medal, Ives; optics, Ives medal.

*Ives Medal Citation—Arthur Francis Turner.* In recognition of his leadership in pioneering the methods of design and fabrication of multilayer evaporated films; his originality in applying multilayer systems to the solution of practical optical problems; and his effectiveness as an educator, communicating to others the methods and principles he developed during a lifelong devotion to optical physics.

- 14646.** Lauritzen, J. I., Jr., Zwanzig, R., **Dielectric relaxation of a single axis rotator with two equivalent sites**, *Advan. Mol. Relaxation Processes* 5, 339-361 (1973).

Key words: dielectric loss; relaxation; single axis rotator; site model; Smoluchowski's equation.

The dielectric relaxation of a single axis rotator subject to a sinusoidal potential due to the crystalline field has been calculated for a polycrystalline sample, assuming the relaxation of the dipolar orientation is governed by Smoluchowski's equation. For large values of the potential barrier the dielectric loss corresponds to that due to a two site model. For intermediate values of the potential barrier the dielectric loss corresponds to two slightly broadened Debye loss curves which may be sufficiently separated to be bimodal.

- 14647.** Julienne, P. S., Krauss, M., **Molecule formation by inverse predissociation**, (Proc. Symp. on Interstellar Molecules, Charlottesville, Va., Nov. 4-7, 1971), Paper in *Molecules in the Galactic Environment*, M. A. Gordon and L. E. Snyder, Eds., pp. 354-373 (John Wiley and Sons, New York, N.Y., 1973).



**Key words:** Bates mechanism; Feshbach-type resonance states; inverse predissociation; molecule formation; non-adiabatic interactions; radiative association; two-body recombination rates.

One of the dominant mechanisms for interstellar molecule production has long been thought to be radiative association. We wish to broaden the usual understanding of this process and present a theory for molecule formation through inverse predissociation which must be considered along with the Bates mechanism as being important under interstellar conditions. Although molecule formation by a two-body collision can occur only upon continuum to bound radiation, we will demonstrate that the presence of Feshbach-type resonance states embedded in the continuum must be considered. Thus, two colliding ground state atoms may populate excited bound molecular electronic states which radiate to produce a stable molecule. This mechanism can be operative in molecules for which the direct continuum emission of the Bates mechanism is not possible. We have calculated the two-body recombination rate constant for OH to be  $\sim 3 \times 10^{-20} \text{ cm}^3 \text{ sec}^{-1}$  above around 20 K. This rate results from the mixing of OH  $A^2\Sigma + v=1$  bound levels with the ground  $X^2\Pi_{3/2}$  continuum by virtue of the breakdown of the Born-Oppenheimer approximation. Preliminary calculations for two-body recombination rates for other molecules indicate that CH, CN, and NO can also be formed through intermediate resonance states with rates exceeding  $10^{-18} \text{ cm}^3 \text{ sec}^{-1}$  at low temperatures. We will present a general theory of radiative association by inverse predissociation, including (1) the scattering formalism for the calculation of the Einstein A coefficient, (2) a classification of the various couplings which are possible, together with simple rules for deciding when they may be important, and (3) results of calculations for the formation rates of specific molecules.

**14648.** Johnson, D. R., Kirchhoff, W. H., **Centrifugal distortion and predictability in the microwave spectrum of formamide**, (Proc. Symp. on Interstellar Molecules, Charlottesville, Va., Oct. 4-5, 1971), Paper in *Molecules in the Galactic Environment*, M. A. Gordon and L. E. Snyder, Eds., pp. 247-253 (John Wiley and Sons, New York, N.Y., 1973).

**Key words:** centrifugal distortion; critical review; formamide; interstellar molecules; microwave spectra.

Recent detection of emission signals from interstellar formamide ( $\text{NH}_2\text{COH}$ ) has stimulated a renewed interest in the laboratory microwave spectrum of this molecule. Previous laboratory investigations of formamide were aimed primarily at obtaining structural parameters and other related information. The spectral observations reported in these early papers have much in common with the available literature on other interstellar molecules. Reported transitions either do not include those accessible to the radio telescopes or were not measured with sufficient resolution to be useful for a positive molecular identification.

The present paper describes a detailed investigation of the effects of centrifugal distortion and nuclear quadrupole hyperfine splitting on the microwave spectrum of formamide. Molecular parameters obtained from this investigation have been used to predict the entire rotational spectrum of  $^{14}\text{NH}_2 \text{ }^{12}\text{C}^{16}\text{OH}$  potentially accessible to the telescopes. The procedures illustrated with formamide may be applied to other molecules to predict interstellar transitions which are difficult to measure in the laboratory.

**14649.** Kessler, E. G., Jr., **Determination of the Rydberg constant from the He II  $n=3-4$  (4686 Å) line complex**, (Proc. Fourth Int. Conf. on Atomic Masses and Fundamental Constants, Teddington, England, Sept. 1971), Paper in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds., pp. 427-434 (Plenum Press, London, England, 1972).

**Key words:** fine structure; helium; Rydberg constant.

Absolute wavelength measurements of some of the fine structure components of the He II transition at 4686 Å ( $n=3-4$ ) are being measured to establish a new value for the Rydberg constant. The He II transition is excited in a cooled-hollow-cathode discharge and is resolved and compared to a standard source by use of a pressure-scanned double Fabry-Perot spectrometer. Problems associated with precision wavelength measurements using pressure-scanned interferometers will also be discussed.

**14650.** Leasure, W. A., Jr., Bender, E. K., **Tire-road interaction noise**, *Proc. Inter-Noise 73 Conf., Copenhagen, Denmark, Aug. 22-24, 1973*, pp. 421-425 (1973).

**Key words:** acoustics; noise (sound); tire noise; transportation noise.

The relative importance of tire noise to overall vehicle noise is established. A general description is then given of the tire engineering process and of tire structures. The important parameters influencing tire noise are discussed, based on presently-available data, followed by an identification of unknown and contradictory areas. The basic mechanisms of tire-noise generation, although not well understood, are investigated largely from a theoretical viewpoint. Areas for future research and development are identified based on gaps in the existing physical data base and a rather primitive level of understanding of noise-generating mechanisms.

**14651.** Snell, J. E., Achenbach, P. R., **Total energy systems: A review of recent NBS activities**, *Proc. Effective Energy Utilization Symp., Drexel University, Philadelphia, Pa., June 8-9, 1972*, pp. 201-233 (June 1972).

**Key words:** central utility systems; electrical power generation; energy conservation; energy costs; integrated utility systems; total energy systems; waste disposal.

This paper briefly reviews and reports on the status of several NBS activities in the area of total energy systems as they relate to the theme of the Drexel Symposium on Effective Energy Utilization. A recent review of the state of the art in total energy systems application, indicated the need for good, concise, operating and performance data on total energy systems to serve as a basis for more effective utilization of this concept to save energy. The Department of Housing and Urban Development requested NBS to assist in the development of a total energy system on the BREAKTHROUGH housing site at Jersey City and to conduct a full-scale field study with appropriate instrumentation to obtain engineering, cost and maintenance data.

In a related effort, NBS, AEC, EPA, and NASA are supporting HUD in a new effort entitled The Modular-Sized Integrated Utility System (MIUS) program. The premise of this 3-phase effort is to demonstrate the potential energy, resource, and cost economies of combining energy-generating facilities and waste disposal facilities on a modular-basis to keep pace with changing patterns and rates of urban growth.

**14652.** Little, J. L., **Impact of the ASCII code and printing devices on conventions for alphanumeric display terminals: Part 1**, *Commun. Soc.* **10**, No. 1, 7-10 (Mar. 1973); **10**, No. 2, 6-11 (May 1973).

**Key words:** alphanumeric displays; ASCII Code; cathode-ray-tube displays; control functions; display terminals; interactive terminals; remote computer terminals; soft copy; test editing displays; user control functions; visual displays.

This paper reviews briefly the evolution of the American Standard Code for Information Interchange (ASCII) and its international version (ISO R-646). It also reviews the evolutionary impact of typewriters, teletypewriters, and the ASCII code on conventions now employed in alphanumeric display terminals. It



shows a proposed keyboard layout, some approved graphic subsets of ASCII, and some codes used in computers. Current developments in the representation of extended versions of ASCII in 7 and 8 bits are given. Proposed code assignments of control functions for alphanumeric display terminals are also included, with a warning that their standardization is under the jurisdiction of the American National Standards Institute's Technical Committee X3L2 on Character Codes.

**14653.** Keplinger, M. S., **The case for the invisible copies**, *Rev. Int. Droit Auteur*, pp. 2-31 (1971).

Key words: computers; copyright; information storage and retrieval; infringement; input; intellectual property; law.

The problem of control of the use of copyrighted works in computerized information storage and retrieval systems is discussed. It is concluded that such input may be considered copyright infringement under the current Copyright Revision Bill as interpreted through the teachings of recent court decisions, as well as being an infringement under the current copyright statute. Since the input of this material may be assumed to be infringement, a method for control of the author's right must be devised to protect the author and provide for efficient dissemination of the information. To aid in this control a clearinghouse for copyright concept is suggested.

**14654.** Olsen, L., Baumgarten, G. P., **Gas flow measurement by collection time and density in a constant volume**, (Proc. Symp. on Flow—Its Measurement and Control in Science and Industry, Pittsburgh, Pa., May 10-14, 1971), Chapter in *Flow—Its Measurement and Control in Science and Industry*, R. B. Dowdell, Ed., I, 1287-1295 (Instrument Society of America, Pittsburgh, Pa., 1971).

Key words: calibration; critical flow; gas flow; measurement; nozzles, volumetric.

A method for the accurate measurement of gas flows is described. This method utilizes a valve to divert the flow to a tank of known volume over a measured calibration time interval. Measurements of pressure and temperature (for gas density) are made when the gas within the tank is at a stationary equilibrium condition. The density increase from essentially zero density within the known volume over the measured time interval permits a determination of the mass rate of flow. The flow measurement apparatus and air treatment system consisting of a centrifugal compressor, air dryer, filters, receiver tank, meter runs, nozzles, diverter valve, collection tank and instrumentation are described. A discussion of the procedures and errors in the measurement of pressures, temperatures, volume of the collection tank and timing of the diverter valve is included. The effects of these individual errors on the overall uncertainty of the gas flow measurement is considered. Ten sonic flow nozzles with throat diameters ranging from 0.14234 to 1.29841 in. were calibrated at upstream pressures to 95 psig and flow rates to 2700 SCFM. On the basis of error analysis and comparisons with calibrations in a bell-type prover, the overall uncertainty of these calibrations is estimated to be about 0.11 percent.

**14655.** Ruegg, F. W., Johnson, D. P., **Dynamics of the bell prover**, (Proc. Symp. on Flow—Its Measurement and Control in Science and Industry, Pittsburgh, Pa., May 10-14, 1971), Chapter in *Flow—Its Measurement and Control in Science and Industry*, R. B. Dowdell, Ed., I, 1297-1307 (Instrument Society of America, Pittsburgh, Pa., 1971).

Key words: bell prover; dynamics of provers; flow measurement; gas flow measurement; prover design.

The bell prover is widely used for gas flowrate measurement by timing a known stroke of the bell as it rises, with presumably constant speed, from a bath of sealing liquid. A motion analysis of the coupled fluid and mechanical parts of the prover system

has been made to guide experiments, and to determine dynamic use criteria and measurement errors associated with transient oscillatory motions. Simultaneous differential equations for the motions of the bell, sealing liquid, and gas are presented as a basis for a computer simulation of prover performance. Motion of the bell is considered as affected by the gas pressure therein, by the masses in motion, by viscous drag force and adherence of liquid. Pressure and gravity forces, and viscous flow resistance, affect the liquid motion. Gas pressure in the bell is affected by all the motions and by the gas content. Various methods of damping initial transient motions are included in the analysis.

**14656.** Wright, R. N., Yokel, F. Y., **A concept for limit states design**, *Proc. ASCE-IABSE Int. Conf., Bethlehem, Pa., Aug. 21-25, 1972, Conf. Preprints on Planning and Design of Tall Buildings*, A, 395-399 (1972).

Key words: design mode; limit states design; load; performance criteria; reinforced concrete; reliability; resistance mode; safety; serviceability; stability; structures.

The state-of-the-art reports presented in behalf of Committee 26 are summarized in this paper. Basic concepts and terminology associated with limit states design are discussed and a more general approach is suggested in which scheme-independent performance criteria would be used as a common basis for criteria for limit states design for all material applications. This approach would permit consistency among various material oriented design philosophies.

**14657.** Wright, R. N., **Buckling of plane or prismatic structures**, *Proc. RILEM Colloque Int. Symp., Buenos Aires, Argentina, Sept. 13-18, 1971*, pp. 1-13 (Instituto Nacional de Tecnologia Industrial, Buenos Aires, Argentina, 1971).

Key words: buckling; computers; experimental methods; instability; models; structures.

The papers in this topic address the purposes for experimental analysis of plane and prismatic structures. The report discusses papers dealing with the behavior of reinforced and prestressed concrete structures and metal structures. Within each category, local instability, member instability, and instability of assemblages are considered in the cited order. Finally, papers are discussed which treat aspects of experimental technology that are independent of the structural technology.

**14658.** Wilson, W. K., **Test methods for determining the effect of various treatments on paper**, *Proc. Int. Inst. for Conservation of Historic and Artistic Works (IIC) Congress, Lisbon, Portugal, Oct. 9-13, 1972*, pp. 985-994 (1972).

Key words: paper; paper test methods; restoration; restoration of paper; test methods for paper; treatment of paper.

Several methods are described that may be used in the evaluation of the effects of various restoration treatments on paper documents and works of art. References are given to standard methods and to other sources of information that would be of value to the restorer. The necessity for judging each situation as a separate entity is emphasized.

**14659.** Rosenstein, M., Levine, H., McLaughlin, W. L., **A thermosetting radiation-sensing gel for small-volume dosimetry**, (Proc. Fourth Symp. on Microdosimetry, Verbania Pallanza, Italy, Sept. 24-28, 1973), *EURATOM*, J. Booz, H. G. Ebert, R. Eickel, and A. Waker, Eds., pp. 935-950 (Brussels, Belgium, 1974).

Key words: dosimetry; dyes; gels; microdosimetry; plastics; radiochromism; triphenylmethane dyes; vinyl resins; x-ray detectors.

Thin-film radiation detection systems using triphenylmethane dye derivatives have been developed previously, and their



dosimetric properties have been described in the literature. Until the present work, the solid activator matrix that best sensitized radiolytic dye production was gelatin. Gelatin has the serious problems of dimensional instability and migration of the dye formed after irradiation. The improved activator matrix described here has potential wide application as a radiation detector and imaging system. The dosimeter response results from conversion of the dye precursor to the colored dye, and is a nearly linear function of absorbed dose. Due to the nonturbid matrix, image resolution of 1  $\mu\text{m}$  can be achieved using microdensitometry.

The most successful formulation of those investigated to date contains: a triphenylmethane dye precursor; a specific combination of monomers and polymers, which constitute the activator matrix; and a polymerization initiator. The thermosetting formulation can be molded into a solid glassy resin. Its elemental constituents are C, H, N, and O, and its mass energy absorption coefficient for photons above 200 keV is within 4 percent of that for water and muscle. Down to at least 25 keV, there is no significant variation of dosimeter response with photon energy. Variation of response with ambient temperature during irradiation of the system, relative to room temperature, is less than  $\pm 5$  percent between 0-50  $^{\circ}\text{C}$ . After irradiation and a slight initial 24-hour color buildup, the image is stable for about 1 month. Then a gradual fading occurs. With a 2 mm-thick gel, absorbed doses of 10 krad can be detected with precision limits of 5 percent.

**14660.** Suzuki, G., Hendrickson, R., Donaldson, J., **Quantitative methods in decisionmaking**, Chapter VI in *Management: Concepts and Practice*, F. R. Brown, Ed., pp. 115-155 (Industrial College of the Armed Forces, Ft. McNair, Washington, D.C., 1972).

Key words: decisionmaking; methods; models.

This paper is a revision of Chapter VIII of a handbook used by the Industrial College of the Armed Forces. The handbook has the full title *National Security Management-Management: Concepts and Practice*, and is required reading for students attending the College. Chapter VIII is one of three chapters of Part II of the book dealing with the general subject *Quantitative Tools for Management*. The intent of the chapter is to introduce the reader, who is assumed to have no knowledge of the subject, to the principal elements and kinds of decision processes that occur in operations that require explication and analysis. The chapter is divided into nine sections, whose organization and content lead the reader through an ordered development of the material, dealing with the qualitative and quantitative aspects of the problems likely to be faced and the practicable methods used in the formulations and solutions of these problems. Optimizing and non-optimizing analyses are covered appropriately for the needs of the intended audience of the book. The authors have tried to state the limited utility of formal mathematical methods and have apprized the reader of the fundamentals of operations research as they contribute to problem-solving and analysis of operational situations.

**14661.** Wright, J. R., Herron, W. R., **Response to "J. B. Dick Report,"** *Proc. 5th CIB Congress on Research into Practice. The Challenge of Application, Paris, France, June 1971*, pp. 275-279 (1971).

Key words: BREAKTHROUGH; building performance; construction; contracting; performance assessment; performance concept; performance products; performance testing; user needs.

This paper responds to a provocative paper prepared by Mr. J. B. Dick, Director, Building Research Station in England, for the 5th CIB Congress, June 22-30, 1971, at Versailles, France, entitled "Design Aids: Evaluation Methods for Buildings, Components and Materials." The intent of this paper is to defend the

Performance Concept and its application to building construction. Such a defense must dispel misconceptions which have developed from the limited size of past demonstration projects based on this concept. If these false beliefs are not recognized, they could seriously limit future development and use of the performance concept.

**14662.** Wright, J. R., Leyendecker, E. V., **Measuring the performance of industrialized housing under "Operation Breakthrough,"** *Proc. 5th CIB Congress on Research into Practice. The Challenge of Application, Paris, France, June 1971*, pp. 303-308 (1971).

Key words: certification; guide criteria; innovative housing; Operation BREAKTHROUGH; PERFORMANCE criteria; performance evaluation.

The National Bureau of Standards, Department of Commerce, is conducting the technical evaluation of "Operation BREAKTHROUGH" housing systems for the Department of Housing and Urban Development. This paper discussed the BREAKTHROUGH team's development of performance criteria and describes the philosophy used in developing the criteria. An example of how the criteria can be used in the evaluation process leading to certification is discussed.

**14663.** Somes, N. F., Corley, W. G., **Circular openings in webs of continuous beams**, *Amer. Concrete Inst. Spec. Publ. 42-17*, pp. 359-398 (1973).

Key words: beams; design criteria; joists; openings; shear strength; tests; web.

The second phase of a comprehensive investigation is reported. Tests show the effect on strength and behavior of circular web openings in continuous lightweight-aggregate concrete joist floors. Principal variables were size, location, reinforcement and spacing of openings. Based on the findings, design recommendations are presented.

**14664.** Muehlhause, C. O., **Setting safety standards via risk-benefit analysis**, *Proc. PLP-73 Product Liability Prevention Conf., Newark, N.J., Aug. 22-24, 1973*, pp. 137-140 (1973).

Key words: acceptance of risk; consumer product safety; perception; risk-benefit analysis; standards.

The problem which a hypothetical regulator would face who is intent on setting safety standards for consumer products utilizing the "method" of risk-benefit analysis is examined. It is shown that in addition to a scarcity of difficult-to-produce data certain conceptual problems regarding the manner in which risk to personal health and safety is to be embodied in cost-benefit analysis is also present. A particular formulation which recognizes the acceptance and misperception of risk as well as its cost is presented.

**14665.** Locke, J. W., **Data limitations for the prediction of dangerousness**, (Proc. Conf. on Preventive Detention Center for Continuing Education, University of Chicago, Chicago, Ill., Oct. 28-30, 1969), Paper in *Preventive Retention*, pp. 117-131 (Urban Research Corp., Chicago, Ill., 1969).

Key words: bail; criminal justice; dangerousness; data collection; prediction; statistical analysis.

Statistical data used in past studies to describe criminal activity of people while on pre-trial release have been questioned by many familiar with the Criminal Justice System because of their limited scope. This paper describes some of the problems associated with the development of a substantially broader data base. It also includes a discussion of incompleteness, inaccuracy and other inadequacies of available court data for developing methods of predicting dangerousness of individuals who enter the Criminal Justice System. Brief reference is made to dan-



gerousness criteria and to prediction techniques which may have application in deciding whether or not to release defendants before trial. The discussion is based upon the early stages of a pilot study being conducted for the National Institute of Law Enforcement and Criminal Justice.

**14666.** Fano, U., Martin, W. C., **Z-dependence of spin-orbit coupling**, Paper in *Topics in Modern Physics*, W. E. Britten and H. Odabasi, Eds., pp. 147-152 (Colorado Assoc. Press, Boulder, Colo., 1970).

Key words: coupling-strength; spin-orbit coupling.

Experimental evidence on the spectroscopic spin-orbit strength parameter for p electrons,  $\zeta_p$ , for neutral atoms of all atomic numbers Z is represented rather closely by the empirical formula

$$\zeta_p n^{*3} = 0.450 Z^{2.33} \text{ cm}^{-1}.$$

A few comments are made regarding alternative representations of spin-orbit coupling.

**14667.** Klein, R., **Gas-solid interactions: Laboratory paradigms for reactions on interstellar grains**, (Proc. Conf. on Interstellar Molecules, Charlottesville, Va., Oct. 4-5, 1971), Paper in *Molecules in the Galactic Environment*, M. A. Gordon and L. E. Snyder, Eds., pp. 390-398 (John Wiley and Sons, New York, N.Y., 1973).

Key words: interstellar molecules; low temperature chemistry; surface reactions.

Reactions observed at temperatures below 150 K include those of atomic hydrogen and atomic oxygen in their ground electronic states interacting with condensed olefinic hydrocarbons. These serve as models for consideration of reactions on interstellar grains. The atomic hydrogen adds to the olefin on the surface with the resultant alkyl radicals diffusing into the interior and reacting further. Atomic oxygen diffuses into and reacts in the condensed volume. These reactions are discussed in terms of molecule formation. It is noted that the activation energy barriers are sufficiently high, both for reaction and diffusion, that it is unlikely that these reactions may serve as useful models for molecular syntheses in the H-I region.

**14668.** Unassigned.

**14669.** Wright, J. R., Achenbach, P. R., Editors, **Energy Conservation in Buildings**, (Proc. Scientific American Roundtable of Energy Conservation in Buildings, New York, N.Y., Aug. 29, 1973), *Sci. Amer. Spec. Publ.*, 79 pages (1973).

Key words: buildings; conservation; energy; energy sources; measurement; simulation; thermal efficiency.

More base data is needed with respect to energy resources and us. Better measurement in terms of both techniques and values is suggested in the physical science aspects of energy and in our understanding of man and the energy-related attributes he requires of his shelter. Americans must stop wasting energy and at the same time develop new energy technologies. The roundtable offered numerous suggestions for the near-, mid- and long-range futures.

**14670.** Meese, W. J., **Rules for the operation of electric supply and communication lines and equipment**, Part 4 (Sections 40-43) in the *National Electrical Safety Code*, Sixth Edition, ANSI C2.4-1973, pp. 273-313 (IEEE, New York, N.Y., 1973).

Key words: communication industry safety; electrical safety; operation of communication systems; operation of electrical supply systems; public utility safety; safety work rules.

This standard contains Part 4 of the National Electrical Safety Code and supersedes ANSI C2.4-1939, NBS Handbook H34

and pages 305 through 358 of NBS Handbook H30. Part 4 of this Code contains work rules applying to the construction, maintenance, and operation of electric-supply and communication lines and equipment of public utilities and similar systems. These rules are intended to embody the requirements which are most important from the standpoint of safety to employees and to the public.

**14671.** Meese, W. J., **Safety and safety standards for electric supply and communication facilities in utility tunnels**, *Proc. American Public Works Assoc., Henniker, N.H., Aug. 16-20, 1971, Special Report 42*, pp. 95-98 (New England College, Henniker, N.H., 1972).

Key words: coordination of utility facilities; national electrical safety code; safety standards for utility tunnels; underground communication facility; underground electric facilities; utility tunnel safety.

In recent years many of the facilities of electric and communication utilities have been installed underground, principally for environmental reasons. Installation and maintenance of these facilities, along with the facilities of several other utilities is becoming difficult and costly, and the necessity of frequent street openings for access to utilities is burdensome to the public and to businesses in the vicinity. Better coordination of utility and other public works facilities is needed. Because of this, the utility tunnel concept is receiving much study and utility tunnel safety is a primary consideration.

**14672.** Hilsenrath, J., **Input techniques for technical information**, *Proc. Forum of Federally Supported Information Analysis Centers, NBS, Gaithersburg, Md., May 17-18, 1971*, pp. 71-88 (Available as PB208-018 from the National Technical Information Service, Springfield, Va. 22161, Jan. 1972).

Key words: computer-assisted printing; computer input; electronic typesetting; input techniques; keyboarding conventions; phototypesetting; text automation.

A summary is presented of recent progress at NBS in the automation of book production through the development of techniques for computer-assisted phototypesetting. The strength of the system rests on general-purpose edit-insertion programs and other general-purpose programs which accept a variety of input media. The programs take existing files on punched cards or computer tapes; or Magnetic Tape Selectric Typewriter (MTST) cartridges; or files keyboarded on-line to a time-shared text editing system; and transform them to match the requirements of the phototypesetting system at the U.S. Government Printing Office (GPO).

Examples are shown of finished text consisting of upper and lower case Roman and Greek characters, subscripts and superscripts keyboarded on a variety of input devices. The examples are from input on punched cards, from a 44 key Selectric terminal and from a "scripting" teleprinter capable of typing 126 characters in two colors in inferior, superior or main line positions.

**14673.** Hall, J. L., **Sub Doppler spectroscopy, methane hyperfine spectroscopy, and the ultimate resolution limits**, *Proc. Aussois Conf. on Spectroscopy Without Doppler Broadening, Aussois, France, May 1973*, pp. 105-125 (1973).

Key words: laser spectroscopy; methane; molecular hyperfine spectra; saturated absorption spectroscopy; ultrahigh resolution.

The most recent results on saturated absorption spectroscopy of methane are presented. 2nd order Doppler shift and photon recoil shift are shown to be some of the limiting factors of this technique.



**14674.** Steiner, B., **New needs for accurate optical radiation measurements. II. A growing concern of the National Bureau of Standards and of American CIE**, *Proc. Conf. on Photometry and Colorimetry, Varna, Bulgaria, June 27-30, 1973*, pp. 39-45 (Dec. 1973).

Key words: energy crisis; health; meteorology; photometry; pollution monitoring; radiometry; remote sensing; safety.

Moreover, commercial needs and concern for more accurate optical radiation measurement are paralleled by growing public problems whose solutions depend strongly upon improved radiometry and photometry. The recent rapid growth of the electro-optics industry has both caused and exacerbated the severity of the measurement difficulties. The resulting great technical effort required can be justified by the public issues involved as well as by the commercial impact. Examples of these public issues are: the health issues of phototherapy and clinical analysis; the safety issues of potential destruction of the protective earth ozone layer, biomedical engineering, and transportation; the energy crisis; meteorology; pollution monitoring; and remote sensing. The effort to achieve a larger and more coordinated approach to the related radiometric and photometric problems have been organized by American CIE TC 1.2 through its creation of the Council for Optical Radiation Measurement. The purpose, structure, and activity of the Council are described.

**14675.** Mandel, J., Steel, M. N., Sharman, L. J., **National Bureau of Standards analysis of the ASTM interlaboratory study of DOC/FF 3-71 flammability of children's sleepwear**, *Amer. Soc. Test. Mater. Stand. News*, pp. 9-13 (May 1973).

Key words: children's sleepwear; flammability; flammability standard; flammability test method.

ASTM Committee D-13 on Textile Materials carried out an interlaboratory study on the test method given in DOC FF 3-71, Standard for the Flammability of Children's Sleepwear. Sixteen laboratories and eight fabrics were involved. D-13's conclusions were that the study demonstrated that laboratories do not obtain the same "pass-fail" results when testing the same fabrics with DOC FF 3-71 as written and, in fact, gross differences in reproducibility were obtained. The same test data was analyzed at NBS. The analysis reported in this paper leads to conclusions contrary to those reported by D-13. The NBS report shows theoretically that with a go-no go test such as that for children's sleepwear, the probability of complete agreement between laboratories is attained only when the material under test is either so far superior to the test method requirements or so far inferior to them that unavoidable test method fluctuations have no effect on the outcome of the test. For a fabric that is only two percent defective, the probability of complete agreement between 16 laboratories is down to 72 percent. The data provide no evidence to support D-13's conclusion that gross differences in reproducibility are obtained.

**14676.** Kruger, J., Hayfield, P. C. S., **Ellipsometry in corrosion testing**, (Proc. Symp. on State-of-the Art of Corrosion Testing, Toronto, Canada, June 21-27, 1970), Chapter 32 in *Handbook on Corrosion Testing and Evaluation*, W. H. Ailor, Ed., pp. 783-831 (John Wiley & Sons, New York, N.Y., 1971).

Key words: corrosion; electrochemistry; ellipsometry; oxidation; thickness measurements.

Because corrosion processes are strongly affected by the presence of thin films, the optical technique of ellipsometry which measures the thickness of these films and their optical properties is a valuable tool for corrosion research and testing. This technique measures the change in the state of polarization upon reflection of polarized light from a metal surface and relates these changes to the thickness and refractive index of films formed on this surface while it is immersed in an aqueous solu-

tion or in gaseous environments. Since experimentally the technique only requires that one provide a means for light to be reflected from a passive or corroding surface, it can be combined with electrochemical or diffraction techniques.

Numerous examples of ways in which ellipsometry can be applied to corrosion science and engineering measurements of film formation and dissolution kinetics and changes in film and metal surface properties are described.

**14677.** Murphy, T. A., Sengers, J. V., Sengers, J. M. H. L., **Analysis of the pressure of gases near the critical point in terms of a scaled equation of state**, *Proc. Sixth Symp. on Thermophysical Properties, Atlanta, Ga., Aug. 6-8, 1973*, P. E. Liley, Ed., pp. 180-188 (The American Society of Mechanical Engineers, New York, N.Y., 1973).

Key words: carbon dioxide; critical phenomena; critical region of gases; equation of state; parametric equation; scaling laws.

The anomalous thermodynamic behavior of gases near the critical point can be described in terms of scaling laws. In recent years a parametric equation of state, the so-called Linear Model, has been proposed that incorporates the scaling laws. We have developed a method which enables us to determine optimized Linear Model parameters by fitting experimental P-V-T data in the critical region. As an illustration of the method we discuss some preliminary results obtained for CO<sub>2</sub> in the critical region.

**14678.** Haar, L., Gallagher, J., **Heat capacity for gaseous ammonia**, *Proc. 6th Symp. on Thermophysical Properties, Atlanta, Ga., Aug. 6-8, 1973*, P. E. Liley, Ed., pp. 228-237 (The American Society of Mechanical Engineers, New York, N.Y., 1973).

Key words: ammonia; heat capacity; ideal gas; PVT data; PVT surface; temperature scale; thermodynamic consistency.

Several classic experiments for gaseous ammonia are shown to be thermodynamically consistent and accurate almost within their individual scatter. This feature is the basis for the extension of the range of the constant pressure heat capacity measurements (by a factor of 2 in temperature and 5 in pressure) with no appreciable loss of accuracy. For this purpose the previously calculated  $C_p^\circ$  values for the ideal gas are taken as bench-mark data. The real gas  $C_p$  values are tabulated for temperatures from  $-30^\circ \leq t \leq 325^\circ \text{C}$  and pressures up to 125 bar. Over most of this range the uncertainty is several tenths percent.

**14679.** Isler, M. A., Stenbakken, G. N., **Mechanically actuated switches for burglar alarm systems**, *NILECJ-STD-0302.00*, 18 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., May 1974).

Key words: burglar alarm sensor; burglar alarm system; door switch; mechanically actuated switch; perimeter sensor; switch.

This standard establishes performance criteria for mechanically-actuated electrical switches intended for use in protective intrusion alarm circuits to monitor the position of doors, windows, etc. These devices cause the initiation of an alarm signal to a police panel, central station, or local audible alarm device. Included are requirements and test methods for performance, electrical properties and materials. The performance characteristics addressed are those that affect the false alarm susceptibility of the device. This standard does not provide performance criteria for the ability of these devices to resist attempts to defeat them through physical or surreptitious attack.



**14680.** Mills, R. M., Yee, K. W., **Walk-through metal detectors for use in weapons detection**, *NILECJ-STD-0601.00*, 26 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., June 1974).

Key words: metal detections; performance standards; weapon detection.

A standard has been developed to establish performance requirements and test methods for the detection capability and general characteristics of walk-through metal detectors.

**14681.** Hord, J., **Cavitation in liquid cryogenics. IV. Combined correlations for venturi, hydrofoil, ogives, and pumps**, *NASA CR-244B*, 103 pages (National Aeronautics and Space Administration, Washington, D.C., Oct. 1974).

Key words: cavitation; cryogenics; hydrofoil; impellers; inducers; ogives; pumps; venturi.

This is the fourth and final volume on the results of a series of experimental and analytical cavitation studies. Previous volumes contain basic analyses and experimental data for a venturi, a hydrofoil, and three scaled ogives. Cross-correlation of the developed cavity data for these five hydrodynamic bodies is performed in this report. The data, for liquid hydrogen and liquid nitrogen, are correlated by using the extended theory derived in Volume II (CR-2156). The new correlating parameter, MTWO, improves data correlation for these stationary bodies and for pumping equipment. The results of this study are applied to the cavitating pump impeller and inducer data published by the NASA Lewis Research Center. Existing techniques for predicting the cavitating performance of pumping machinery are extended to include variations in flow coefficient, cavitation parameter, and equipment geometry. The new predictive formulations hold promise as a design tool and universal method for correlating pumping machinery performance. Application of these predictive formulas requires prescribed cavitation test data or an independent method of estimating the cavitation parameter for each pump. The latter would permit prediction of performance without testing; potential methods for evaluating the cavitation parameter prior to testing are suggested. Directions for future work are indicated.

**14682.** Clifton, J. R., Beeghly, H. F., Mathey, R. G., **Nonmetallic coatings for concrete reinforcing bars**, *FHWA-RD-74-18*, 85 pages (Available from the National Technical Information Services, Springfield, Va. 22161, Feb. 1974).

Key words: bridge decks; chloride ions; concrete; corrosion; deicing salts; epoxy coatings; organic coatings; steel reinforcing bars.

This work was undertaken to ascertain the feasibility of using organic coatings, especially epoxies, to protect the steel reinforcing bars embedded in concrete of bridge decks from rapid corrosion. This corrosion is caused by the chloride ions from the most commonly applied deicing salts, sodium chloride and calcium chloride. Altogether, 47 different coating materials were evaluated to some extent, consisting of: 21 liquid and 15 powder epoxies; 5 polyvinyl chlorides; 3 polyurethanes; 1 polypropylene; 1 phenolic nitrile, and one zinc rich coating. The chemical and physical durabilities, chloride permeabilities, and protective qualities of coatings were assessed. The bonds between coated and uncoated bars and concrete were measured by both pullout and creep tests.

The results indicate that both epoxy and polyvinyl chloride coatings, if properly applied, should adequately protect steel reinforcing bars from corrosion. However, only the epoxy coated bars had acceptable bond and creep characteristics when embedded in concrete. The powder epoxy coatings overall performed better than the liquid epoxies, and four powder epoxy

coatings have been identified as promising materials to be used on reinforcing bars embedded in concrete decks of experimental bridges.

**14683.** Yonemura, G. T., **Image quality criterion for the identification of faces**, *LESP-RPT-0303.00*, 24 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., May 1974).

Key words: acutance; facial identification; identification in photographs; image quality; modulation transfer function.

This report describes an experiment, the resulting data, and recommendations concerning an image quality criterion for identification of faces in a photograph. It relates the psychological levels of visual performance to performance of photographic equipment in terms of acutance and modulation transfer function.

**14684.** Rush, J. J., **Study of large-amplitude vibrations in molecules by inelastic neutron scattering**, (Proc. Conf. Critical Evaluation of Chemical and Physical Structural Information, Dartmouth College, Hanover, N.H., June 24-29, 1973), Paper in *Critical Evaluation of Chemical and Physical Structural Information*, D. R. Lide, Jr., and M. A. Paul, Eds., pp. 369-385 (National Academy of Sciences, Washington, D.C., 1974).

Key words: barriers to rotation; large amplitude vibrations; momentum transfer; neutron scattering; optical spectroscopy; torsional vibration.

The application of neutron inelastic scattering to the study of large amplitude intramolecular (primarily torsional) vibrations in hydrogenous molecules is discussed. In principle the neutron technique provides an excellent complement to optical techniques, due in part to the fact that large-amplitude modes, which are sometimes inactive or weakly active in IR or Raman spectra, provide intense peaks in neutron spectra. However, relatively poor ( $\sim 10 \text{ cm}^{-1}$ ) instrumental resolution and Doppler broadening effects in fluid phases sometimes cause significant complications in experiment and interpretation. Neutron spectral results on several prototype methyl-substituted molecules are presented and compared with relevant optical data. Some of the limitations and pitfalls of neutron molecular spectroscopy are discussed along with the difficulties in deriving potential barrier parameters from a limited number of torsional mode assignments.

**14685.** Lafferty, W. J., **Determination of potential functions and barriers to planarity for the ring-puckering vibrations of four-membered ring molecules**, (Proc. Conf. Critical Evaluation of Chemical and Physical Structural Information, Dartmouth College, Hanover, N.H., June 24-29, 1973), Paper in *Critical Evaluation of Chemical and Physical Structural Information*, D. R. Lide, Jr., and M. A. Paul, Eds., pp. 386-409 (National Academy of Sciences, Washington, D.C., 1974).

Key words: barrier heights; four-member ring molecules; infrared spectroscopy; microwave spectroscopy; Raman spectroscopy; ring-puckering.

Experimental and model errors in the determination of barrier heights in four-membered ring molecules are discussed.

**14686.** Rush, J. J., Livingston, R. C., Rosasco, G. J., **Raman scattering study of crystal dynamics and order-disorder transitions in alkali hydrosulfides**, *Solid State Commun.* **13**, 159-162 (1973).

Key words: alkali hydrosulfides; crystal dynamics; Raman scattering.

Raman spectra have been measured for NaSH, CsSH and RbSH over a range of temperatures from 85 to 400 K. The



results show that the order-disorder phase transitions in these solids are associated with significant changes in the details of their crystal dynamics. In addition the Raman spectra provide clear evidence for the existence of previously unobserved low-temperature phases in each compound, which apparently involve total ordering of the  $\text{SH}^-$  ions.

- 14687.** Kaldor, A., Braun, W., Kurylo, M. J., **Infrared laser enhanced reactions:  $\text{O}_3 + \text{SO}$** , *J. Chem. Phys.* **61**, No. 7, 2496-2499 (Oct. 1, 1974).

Key words: apparatus and methods; chemiluminescence; emission spectra; free radicals; kinetics of reactions; lasers, infrared; photochemistry.

Vibrationally excited ozone,  $\text{O}_3^+$ , produced by  $\text{CO}_2$  laser radiation was found to react with  $\text{SO}$  significantly faster than thermal ozone via the chemiluminescent reaction process  $\text{O}_3 + \text{SO} \rightarrow \text{SO}_2(^1B_1) + \text{O}_2(^3\Sigma_g^-)$ . The vibrational rate enhancement of this reaction was  $2.5 \pm 0.6$  at 300 K. This represents the utilization of 27 percent of the available vibrational energy to promote the reaction based on a model assuming involvement of a single vibrational mode. The laser enhanced chemiluminescence measured from 260 to 450 nm was found to exhibit a  $630 \pm 200 \text{ cm}^{-1}$  blue shift. This is interpreted as a partitioning of the available vibrational energy of  $\text{O}_3^+$  in the vibrational manifold of the  $\text{SO}_2(^1B_1)$  product.

- 14688.** Bassett, D. C., Block, S., Piermarini, G. J., **A high-pressure phase of polyethylene and chain-extended growth**, *J. Appl. Phys.* **45**, No. 10, 4146-4150 (Oct. 1974).

Key words: diamond anvil pressure cell; high pressure; polyethylene; polymer; polymorphism.

Optical and x-ray observations of polyethylene have been made at high pressures and temperatures using a gasketed diamond-anvil cell. The experiments confirm the existence of the high-pressure phase previously postulated by Bassett and Turner. The new phase is hexagonal, with orthohexagonal lattice parameters of  $a = 8.4_6 \text{ \AA}$  and  $b = 4.8_8 \text{ \AA}$ . Comparison with the previously measured volume change indicates that there is a decrease in the  $c$  dimension to  $2.4_5 \text{ \AA}$  per ethylene unit in transforming from orthorhombic to hexagonal structures. The likely implication is that the molecules in the hexagonal phase do not have an all-trans conformation. Chain-extended growth is the result of crystallization from the melt into the hexagonal phase, whereas chain-folded growth is the familiar process of melt crystallization into the orthorhombic phase. Chain-extended lamellae are observed to grow outwards behind a growing edge with a permanent narrowed profile, showing that the lamellar thickness is determined in a region extending several microns behind the growth front.

- 14689.** Fong, J. T., **Material symmetry and scalar potentials in nonlinear theory of materials**, *Proc. Conf. on Symmetry Similarity and Group-Theoretic Methods in Mechanics*, Calgary, Alberta, Canada, Aug. 19-21, 1974, pp. 155-166 (1974).

Key words: constitutive equation; continuum mechanics; elasticity; isotropy; material symmetry; mechanical properties; rheology; scalar-potential; strain-energy; thermodynamics; viscoelasticity.

For elastic and viscoelastic materials whose constitutive equations are derivable from scalar potentials, we examine their restrictions due to (a) material symmetry alone, and (b) material symmetry plus additional physical hypothesis. New results on a class of nonlinear viscoelastic materials (Bernstein, Kearsley, and Zapas, 1963) are derived. Applications to the interpretation of experimental data on real materials are discussed.

- 14690.** Soulen, R. J., Jr., Marshak, H., **The use of Josephson junctions for noise thermometry below 1 kelvin**, *Proc. Applied Superconductivity Conf., Annapolis, Md., May 1-3, 1972*, pp. 588-591 (1972).

Key words: beryllium;  $\text{Co}^{60}$   $\gamma$ -ray anisotropy thermometer; Josephson junction; low temperature thermometry; noise thermometry; superconductivity.

Kamper and Zimmerman have demonstrated that a Josephson junction connected in parallel to a resistor converts the Johnson noise voltage fluctuations into frequency fluctuations, and that the variance of these frequency fluctuations is simply related to absolute temperature. In order to make accurate measurements of temperature with this device, a fast data acquisition system consisting of a frequency counter interfaced to a small computer has been developed. This thermometer has been compared to a  $\text{Co}^{60}$   $\gamma$ -ray anisotropy thermometer in the temperature region of .020 to .050 K. Preliminary results indicate agreement to within 5 percent. We have used our results to redetermine the superconductive transition temperature of pure beryllium. Our value is .0228 K, 3mK lower than reported by Falge. Since our thermometers do not depend upon any calibration or extrapolation and only on some accurately and independently determined parameters of each system, our value of  $T_c$  is probably very close to the absolute temperature of the transition.

- 14691.** Wyckoff, J. M., Chilton, A. B., **Dose due to practical neutron energy distributions incident on concrete shielding walls**, *Proc. Third Int. Congress of the International Radiation Protection Association, Washington, D.C., Sept. 9-14, 1973*, pp. 694-699 (Feb. 1974).

Key words: concrete walls; neutron shielding; particle accelerators; rem.

In order to calculate the dose equivalent for persons on the far side of an ordinary concrete shielding wall from a plane parallel source of neutrons, published monoenergetic neutron data and practical neutron spectra have been folded together. Some interpolation of the monoenergetic neutron data, both in energy and slab thickness, was required to prepare the data for computation in steps of  $50 \text{ g/cm}^2$ . The result is a set of useful dose-equivalent data for walls as thick as  $800 \text{ g/cm}^2$  used to shield particle accelerators producing neutrons up to 100 MeV in energy. A simple empirically derived, analytical expression for the dose equivalent for walls of 50 to  $800 \text{ g/cm}^2$  thickness is given with suitable constants for neutron spectra produced by more than 60 selected examples of the following reactions: slow and fast neutron induced fission,  $(\gamma, n)$ ,  $(p, n)$ ,  $(^3\text{He}, n)$ ,  $(\alpha, n)$  and fission  $(\gamma, n)$ .

- 14692.** Wiese, W. L., Kelleher, D. E., **Asymmetries in Stark-broadened Balmer lines**, *Proc. 10th Int. Conf. on Phenomena in Ionized Gases, Oxford, England, Sept. 13-18, 1971*, p. 377 (1971).

Key words: asymmetries; hydrogen lines; line shifts; Stark-broadening.

Small asymmetries have been observed in the Stark-broadened hydrogen lines  $H_\beta$  and  $H_\gamma$ . They are most pronounced in the line wings, where the red wing is about 15 percent stronger than the blue one. Another asymmetry occurs between the two peaks of  $H_\beta$  where the blue peak is about 4 percent higher than the red one. For the central component of  $H_\gamma$  a small red shift is measured. The experimental results are compared with theoretical estimates and qualitative agreement is found. All experimental observations are made from a hydrogen plasma which is generated in a wall-stabilized arc.

- 14693.** Lindamood, G. E., **A collection of mathematical, J. Irreproducible Results** **20**, No. 1, 30 (June 1973).



Key words: humor.

This article is an attempt at mathematically-oriented humor of the sort which occasionally appears in *Mathematics Magazine*. It consists of a list of titles of musical comedies, altered to suggest some mathematical concept, suggested by a fictitious professor to whom similar mathematical whimsy has been attributed in the literature.

- 14694.** Hill, J. E., Furlong, R. R., **ASHRAE cooling load calculation**, *ASHRAE J.*, pp. 61-66 (May 1973).

Key words: ASHRAE handbook; cooling load; equivalent temperature differentials; heat gain.

An attempt has been made to give an overview of the changes in the cooling load calculation methodology as appears in Part 1, Chapter 22 of the 1972 ASHRAE Handbook of Fundamentals. The distinction between heat gain, cooling load and heat extraction rate is made. The basis for calculating an instantaneous rate of heat gain for a space is given. Particular emphasis is given to the component of gain that occurs through exterior walls and roofs. The tables of equivalent temperature differentials that appear in the chapter are completely changed from those that appear in the 1967 edition. The way the values of TETD were calculated and are intended to be used are explained. In addition, the procedure of converting an instantaneous rate of total heat gain to an instantaneous space cooling load (as outlined in Part 1, Chapter 22) is explained and discussed in reference to other methods currently in use.

- 14695.** Ayres, T. R., Linsky, J. L., Shine, R. A., **Stellar model chromospheres. II. Procyon (F5 IV-V)**, *Astrophys. J.* **192**, 93-107 (Aug. 15, 1974).

Key words: late-type stars; line profiles; stellar chromospheres; stellar photospheres.

We derive a model for the chromosphere and upper photosphere of Procyon (F5 IV-V) based on calibrated observations of the K and 8542 Å lines of Ca II, the  $k(2796 \text{ Å})$  line of Mg II, and the K-line wings. We demonstrate the feasibility of our model synthesis approach to derive a preliminary model chromosphere despite the lack of spatial and spectral resolution associated with solar chromospheric studies. Our upper photosphere model is very similar to the radiative equilibrium Procyon model of Strom and Kurucz, and our chromospheric model is similar to the quiet solar chromosphere temperature distribution of Shine in the 6000-8000 K range.

- 14696.** Rupp, N. W., **Clinical use of some dental materials. Part I. Amalgam**, *J. Indiana Dent. Assoc.*, pp. 432-434 (Oct. 1973); **Part II. Composite restorative materials**, 491-495 (Nov. 1973).

Key words: acid etch; burnishing; handling techniques; materials; restorative.

This discussion of selected dental restorative materials covers new developments in both materials and handling techniques. Dental amalgam alloy formulations and the burnishing of restorations at the time of placement are included. Luting agents, esthetic restorations and acid etch enhanced retention are also covered for the information of the practicing dentist. The review has 34 references.

- 14697.** Velapoldi, R. A., Wicks, S. A., **The use of chemical spot tests kits for the presumptive identification of narcotics and drugs of abuse**, *J. Forensic Sci.* **19**, No. 3, 636-656 (1974).

Key words: centroid color charts; color spot tests; drugs of abuse; experimental detection limits; field tests; narcotic identification; narcotics; spot tests; street drugs.

Numbers and colors from the Inter Society Color Council—National Bureau of Standards Centroid Color Charts have

been assigned to the colors produced by the reactions of typical narcotic field test reagents with pure drugs and other substances. A short discussion of the colors produced with street samples of drugs is also given. Flow charts are presented whereby increased selectivity is obtained by multiple reagent testing. Experimental detection limits were obtained for two drugs, heroin and LSD, by a rigorous, statistically meaningful method and for several other drugs by a less rigorous method. Reagent stabilities and temperature effects are also discussed. It is evident that narcotic field test kits can be useful in obtaining presumptive or preliminary information.

- 14698.** Grosskreutz, J. C., **Fundamental knowledge of fatigue fracture**, (Proc. Third Int. Conf. on Fracture, Munich, Germany, Apr. 8-13, 1972), Paper in *Proceedings of Third International Conference on Fracture*, pp. 1-26 (Verein Deutscher Eisenhüttenleute, Dusseldorf, Germany, Apr. 1973).

Key words: fatigue; mechanisms of fatigue; review of fatigue.

The frontiers in our knowledge of fatigue are reviewed here with the aim of describing the current status and the opportunities for fresh approaches to increase our understanding. The principal opportunity is to quantify that which we already know qualitatively. Throughout the paper an attempt is made to connect fundamental knowledge to the technical problems in fatigue which still remain vexing and unsolved.

- 14699.** Velapoldi, R. A., Diamondstone, B. I., Burke, R. W., **Spectral interpretation and kinetic studies of the  $\text{Fe}^{3+} - \text{H}_2\text{SO}_4$  (Zak) procedure for determination of cholesterol**, *Clin. Chem.* **20**, No. 7, 802-811 (1974).

Key words: carbonium ions; cholesterol; enylic ions; isosbestic points; kinetics; reaction mechanisms; steroids; Zak procedure.

Spectral changes and kinetic data presented for the Zak reaction show the pseudo-first-order character of the consecutive oxidative reactions undergone by cholesterol and selected steroid dienes. These data give excellent support to the proposed formation of the homologous series of steroidal enylic cations which are the absorbing species in the spectrophotometric cholesterol determination. Typical thermodynamic quantities of  $\Delta G^\ddagger$ ,  $\Delta H^\ddagger$ ,  $\Delta S^\ddagger$  and  $E_a$  are also reported for several different reactions. Low acetic-sulfuric acid ratios evidently result in the stabilization of the lower members of the homologous enylic series. Although excellent reproducibilities are obtained for premixed and non-premixed Zak reagents, it is necessary to use the premixed reagent if good temperature control is required, as would be the case for kinetic methods of analysis run under the conditions we used. The isosbestic point observed at 503 nm may also be used as an analytical wavelength because it is less sensitive to variables such as temperature, time, and steroid concentration. ( $\ddagger$  symbolizes that the letter to which it is superscript is a thermodynamic parameter for the activated complex and not for the overall reaction.)

- 14700.** Rabinow, J., **The climate for innovation**, (Proc. First Natl. Conf. Dealing with the Problems of the Small Firms in the Research and Development Industry, Washington, D.C., June 12-14, 1972), Paper in *Survival and Growth. The Small R&D Firm*, J. D. Johnson, Ed., pp. 251-261 (1972).

Key words: consulting services; contract R&D; government contracts; innovation; invention; proposal writing; R&D; small business.

My talk will cover the subject of Small R&D Firms and will be addressed to two types of such firms. One is the small company which develops a product for sale and where R&D is a normal proportion of its business. The other part of the talk will be addressed to R&D companies which do research and development



work for industry and Government and whose major effort is not in production.

My talk will criticize both the Government R&D procurement policies and the industry's response. I believe there is considerable inefficiency in the way contract R&D is done, both on the part of the contractor and the contractee.

**14701.** Laufer, A. H., Bass, A. M., **Rate constants for reactions of methylene with carbon monoxide, oxygen, nitric oxide, and acetylene**, *J. Phys. Chem.* **78**, No. 14, 1344-1348 (1974).

Key words: inorganics; methylene; radical; rate constant; singlet; triplet.

Rate constants for some reactions of triplet and singlet methylene have been measured by means of the flash photolysis of ketene with product analysis by gas chromatography. Rate constants for reactions of triplet methylene with NO, O<sub>2</sub>, and C<sub>2</sub>H<sub>2</sub> in helium are  $1.6 \pm 0.1 \times 10^{-11}$ ,  $1.5 \pm 0.1 \times 10^{-12}$ , and  $7.5 \pm 1.0 \times 10^{-12}$  cm<sup>3</sup> molecule<sup>-1</sup> sec<sup>-1</sup>, respectively, over the pressure range of at least 50-700 torr. The rate constant of triplet CH<sub>2</sub> with CO in 700 torr of helium was  $\leq 1.0 \times 10^{-15}$  cm<sup>3</sup> molecule<sup>-1</sup> sec<sup>-1</sup>. Rate constants for reaction of singlet CH<sub>2</sub> with NO, O<sub>2</sub>, CO, and CH<sub>2</sub>CO were  $< 4 \times 10^{-11}$ ,  $< 3 \times 10^{-11}$ ,  $< 9 \times 10^{-12}$ , and  $3.2 \pm 1.2 \times 10^{-11}$  cm<sup>3</sup> molecule<sup>-1</sup> sec<sup>-1</sup>, respectively. The triplet CH<sub>2</sub> reactions were measured relative to  ${}^3\text{CH}_2 + {}^3\text{CH}_2 \rightarrow \text{C}_2\text{H}_2 + (\text{H}_2 \text{ or } 2\text{H})$ . The rate constants for singlet CH<sub>2</sub> were relative to  ${}^1\text{CH}_2 + \text{He} \rightarrow {}^3\text{CH}_2 + \text{He}$ .

**14702.** Dickens, B., Prince, E., Schroeder, L. W., Jordan, T. H., **A refinement of the crystal structure of H<sub>3</sub>PO<sub>4</sub> · 1/2 H<sub>2</sub>O with neutron diffraction data**, *Act. Cryst.* **B30**, Part 6, 1470-1473 (June 1974).

Key words: crystal structure; hydrates; hydrogen bonding; neutron diffraction; phosphates; phosphoric acid.

The hydrogen positions in H<sub>3</sub>PO<sub>4</sub> · 1/2 H<sub>2</sub>O have been determined and the structure refined to  $R_w = 0.022$ ,  $R = 0.027$ , with 1208 reflections of measurable intensity. The general features of the structure are as described by Mighell, Smith & Brown [*Acta Cryst.* (1969). **B25**, 776-781]. The two crystallographically discrete H<sub>3</sub>PO<sub>4</sub> molecules are hydrogen bonded to each other and to the water molecule. The positions of the hydrogens of the water molecule appear to have been affected by H···H repulsion from the H<sub>3</sub>PO<sub>4</sub> hydrogen atoms and the O<sub>w</sub>—H···O (phosphate) hydrogen bonds are markedly non-linear. For P—O—H, the average P—O distance is 1.562 Å, the average O—H distance is 1.010 Å and the average P—O—H angle is 117°. Individual P—O—H angles range from 112.4 to 119.9°. In the water molecule, the average O—H distance is 0.997 Å, and the H—O—H angle is 106.0 (2)°. The four shortest H···H interactions range from 2.161 (3) to 2.290 (3) Å, and may imply H···H van der Waals bonding as in Ca(OH)<sub>2</sub>.

**14703.** Berger, M. J., **Some new transport calculations of the deposition of energy in biological materials by low-energy electrons**, *Proc. 4th Symp. on Microdosimetry, Verbania Pallanza, Italy, Sept. 1973*, pp. 695-711 (Mar. 1974).

Key words: absorbed dose distributions; electrons, delta rays and beta particles; event-size; microdosimetry; transport theory; wall effects.

After some brief remarks about the method of calculation and cross sections, illustrative results are given from recent electron transport calculations. The following topics are discussed: (1) the distribution of absorbed dose in water around point-isotropic and point-monodirectional electron sources; (2) the radial distribution of absorbed delta-ray energy around proton tracks in nitrogen; (3) the frequency mean and energy mean of microdosimetric event-size distributions in small spherical volumes in water, for the case of irradiation by electrons and

tritium beta-rays; (4) the perturbation of event-size distributions in gas-filled cavities due to the presence of surrounding walls.

**14704.** Unassigned.

**14705.** Carpenter, B. S., LaFleur, P. D., **Nitrogen determination in biological materials by the nuclear track technique**, *Anal. Chem.* **46**, No. 8, 1112-1113 (July 1974).

Key words: bovine liver; cellulose nitrate; image analyzing system; microscope; neutron activation analysis; nitrogen; orchard leaves; proton tracks; standard reference materials.

A method has been developed for the determination of nitrogen in biological matrices using the nuclear track technique (NTT). Protons from the nuclear reaction  ${}^{14}\text{N}(n,p){}^{14}\text{C}$ , which is produced by thermal neutrons, leave radiation damaged trails (tracks) which are made visible to optical microscopy by chemical etching. The NTT method has been used for the analysis of leaves and liver with excellent agreement with values obtained using the Kjeldahl technique.

**14706.** Arsenault, R. J., deWit, R., **Distributed glide force between a non-spherical defect and a dislocation**, *Acta Met.* **22**, 819-827 (July 1974).

Key words: Burgers vector; defect; dislocation; glide; inclusion; kink; tetragonal.

The distributed glide force on dislocations due to a  $\langle 100 \rangle$  and a  $[110]$  type non-spherical defect was determined. The distributive glide force does produce a torque on a screw dislocation but it is of no consequence in terms of the effect the defect has on the nucleation of a double kink. It was also proven that the total interaction force with a non-spherical defect is indeed greater for an edge dislocation than with a screw dislocation.

**14707.** Richmond, J. C., **Survey of image quality criteria for passive night vision devices**, *LESP-RPT-0301.00*, 22 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., June 1974).

Key words: acutance; contrast transfer function; edge gradient; image quality; light equivalent background; light induced background; limiting resolution; line spread function; optical transfer function; point spread function.

Image quality is probably the single most important parameter in determining the utility of any optical device. For night vision devices, in particular, image quality is of paramount importance. In looking at two different photographs of the same scene, which are essentially two different images fixed by the photographic process, almost anyone can tell at a glance which has the better image quality, particularly if there is a significant difference in image quality. Objective evaluation of image quality in quantitative terms is not easy, because there are many variables that contribute to image quality, not all of which have been identified, or can be quantitatively evaluated.

This report is a preliminary survey of image quality evaluation techniques that have been described in the literature and discussion of their merits for use in a standard for passive night vision devices.

**14708.** Madden, R. P., **Absolute detectors and the transfer standard problem in the vacuum ultraviolet**, *Proc. Calibration Methods in the Ultraviolet and X-Ray Regions of the Spectrum Symp., Munich, Germany, May 1968*, pp. 111-124 (European Space Research Organization, Munich, Germany, 1968).

Key words: anodized aluminum; chromium; gold; photoelectric yield; radiometric standards; rare gas ionization chamber; thermopiles; tungsten; vacuum ultraviolet.



Thermopiles have been studied extensively for their applicability as radiometric standards in the 500-2000 Å region. Under appropriate conditions and with suitable corrections it appears that they can be used reliably in this spectral region having been calibrated with black-body radiation in the visible. A thermopile and a rare gas ionisation chamber have been used to measure independently the same flux at 584 Å and 735 Å, with an agreement better than the estimated reliability of 3 percent. A search is now under way to find a photocathode with a stable photoelectric yield which, in a photodiode, could serve as a convenient and reliable transfer detector standard for the region below 1400 Å. Completed studies prove conclusively that the photoelectric yield of an ultra-clean surface of tungsten can undergo a dramatic change when contaminated by as little as a fraction of a monolayer. That other photocathodes as well are sensitive to contamination is indicated by studies of the effects of ageing and heating on the photoelectric yield of several materials (e.g., gold, chromium) under ordinary vacuum conditions. Anodised aluminium films show promise as surfaces which have a reliable photoelectric yield.

**14709.** Schaffer, R., *Diagnostic materials for clinical analysis*, (Proc. Int. Conf. on Standardization of Diagnostic Materials, Atlanta, Ga., June 5-8, 1973), Paper 1 in *Bull. Wld. Hlth. Org.* **48**, 715-720 (1973).

Key words: clinical chemistry; clinical standards; diagnostic kits; diagnostic material; standard reference materials for clinical chemistry; standards.

Standardization of diagnostic materials has lagged behind their development and application. The need to improve the accuracy of the results obtained with them has stimulated collaborative efforts to upgrade the quality of the reagents, control materials, and standards used, with the result that specifications for reagents and standards and authoritative standard materials are now available for a number of clinical tests. Achievements thus far and the efforts now in progress are reviewed.

**14710.** Lide, D. R., Jr., *The XYZ's of laboratory frequency measurements*, Chapter in *Molecules in the Galactic Environment*, M. A. Gordon and L. E. Snyder, Eds., pp. 234-245 (John Wiley & Sons, New York, N.Y., 1973).

Key words: gaseous molecules; interstellar absorption lines, microwave absorption lines; microwave spectroscopic data.

The techniques of laboratory measurement of microwave absorption lines of gaseous molecules are reviewed. The various contributions to line widths are discussed with respect to their influence on the accuracy of typical frequency measurements reported in the literature. The reliability of calculated frequencies is discussed, as well as the general problem of identifying interstellar absorption lines on the basis of coincidences with tabulated laboratory frequencies. Useful sources of microwave spectroscopic data are summarized.

**14711.** Ellerbruch, D. A., *Application of measurements of electromagnetic phenomena to oceanography*, *Proc. First UJNR/MEC Symp., Record of the U.S.-Japan UJNR Joint Symp. on Marine Electronics, Tokyo, Japan, Oct. 9, 1972*, pp. 23-30 (Japanese Electrical Industrial Committee, Tokyo, Japan, 1972).

Key words: electromagnetic measurements; oceanography; sea water-return cable.

The U.S. National Bureau of Standards has developed a wide variety of measurement techniques for precisely determining the electromagnetic quantities and performance of electrical networks. Most of these measurements have been reduced to standard laboratory routines. Usually the network is transported into the laboratory, however, many measurements are utilized in the field.

The ocean can be treated as an electrical network. It is dispersive, lossy, inhomogeneous, far from a theoretically perfect medium. Nevertheless the established techniques used to evaluate laboratory sized samples of well-defined media can be used to evaluate the performance of full scale oceanic systems in situ. In those applications the measurement laboratory is transported to the network. NBS has obtained data on the performance of the multiconductor, seawater return, mooring line data line being used by the National Data Buoy Center for deploying their network of moored Environmental Buoys. A variety of measurement techniques were used in this evaluation. Data were obtained in both the time and the frequency domains.

The interaction of electromagnetic waves with the ocean provides a means for sensing and characterizing oceanic parameters. Electromagnetic sensing techniques offer interesting new approaches to the development of oceanic instrumentation. Some of these techniques will be described.

**14712.** Waxman, M., Davis, H. A., Hastings, J. R., *A new determination of the second virial coefficient of carbon dioxide at temperatures between 0 and 150 °C, and an evaluation of its reliability*, *Proc. Sixth Symp. on Thermophysical Properties, Atlanta, Ga., Aug. 6-10, 1973*, pp. 245-255 (Aug. 1973).

Key words: Burnett data reduction; carbon dioxide; nonlinear analysis; second virial coefficient.

Values of the second virial coefficient of carbon dioxide have been determined to an estimated reliability of 0.3 cm<sup>3</sup>/mole from Burnett PVT measurements taken over the pressure range from 2 to 35 bar at six temperatures between 0 and 150 °C. Our values, from -150 to -51 cm<sup>3</sup>/mole, compare favorably with those obtained from a recent correlation of literature values and are in substantial disagreement with the values previously determined from both the Burnett and the piezometer methods by Dadson and coworkers. The nonlinear least-squares analysis of Burnett data and our error analysis are discussed extensively and illustrated with results for carbon dioxide, helium, and ethylene. An algorithm, recently developed by M. Waxman, for the least-squares evaluation of parameters in nonlinear implicit equations, such as the Burnett pressure equation, is described.

**14713.** Tate, E. L., *On the interlibrary loan horizon—non-mechanical*, *Proc. First Annual Federal Interagency Field Librarians Workshop, Washington, D.C., Sept. 24-28, 1972*, pp. 277-282 (1972).

Key words: federal libraries; interlibrary loans.

The paper describes two studies on interlibrary loans sponsored by the Association of Research Libraries. One, published this spring, concerns the characteristics, costs, and magnitude of interlibrary loans in academic libraries; the other, being prepared under contract from the National Commission on Libraries and Information Science, will deal with the feasibility of centralized or regionalized interlibrary loan centers. Comments on the current state of the copyright/photocopying problem are included. Present and proposed projects of the Federal Library Committee Task Force on Interlibrary Loan Arrangements are discussed.

**14714.** Sugar, G. R., *Voice privacy equipment for law enforcement communication systems*, *LESP-RPT-0204.00*, 27 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, D.C., May 1974).

Key words: intelligibility; LESL; NILECJ; performance standard; privacy; scramblers; speech quality; speech scramblers; survey; testing; voice privacy.

Law enforcement agencies are finding an increasing need for voice-scrambling equipment to provide privacy on their two-way radio communication systems. Work is underway at the National



Bureau of Standards, under the sponsorship of the National Institute of Law Enforcement and Criminal Justice (NILECJ), to develop performance standards for voice scramblers. The four areas being considered are speech intelligibility, voice quality, voice privacy, and general system characteristics. This report first defines a set of special terms, then describes a number of types of scramblers that are now available for law enforcement use. Some inherent problems and weaknesses are discussed. The concepts of intelligibility and privacy are explored in detail. The potential contents of the standard are described, and some problems inherent in preparing and using the standard are discussed. The report concludes with some material intended to be of immediate assistance to the prospective purchaser of scramblers: a survey of units now on the market, some hints on how to proceed in the absence of a standard, and a bibliography of technical publications on voice scrambling.

- 14715.** LaFleur, P. D., **Biological matrix standard reference materials for trace element determinations**, (Proc. Int. Conf. on Modern Trends in Activation Analysis in Saclay, France, Oct. 2-6, 1972), *J. Radioanal. Chem.* **19**, 227-232 (1974).

Key words: biological; bovine liver; orchard leaves; standard reference materials; trace elements.

Two new biological matrix Standard Reference Materials, SRM-1571, Orchard Leaves and SRM-1577, Bovine Liver, have been issued by the United States National Bureau of Standards. The content of a number of trace elements has been certified in these materials. The preparation and analytical program of the standards is described; these materials should be of great value in assuring quality control and in developing new procedures for analysis of biological materials.

- 14716.** Saltman, R. G., **Educating public administrators for managing science and technology**, *Pub. Admin. Rev.* **34**, No. 4, 394-396 (July-Aug. 1974).

Key words: administration; education; information; management; public; science; technology transfer.

Public administrators are being forced to increasingly consider science and technology in decisions that they make concerning both plans and operations. In order to manage and control pertinent science and technology and to effectively employ them, the public administrator needs a professional education which gears him for these tasks. Information science and management science are applications-independent tools that the administrator can use extensively to make his operations more efficient, to provide him with the coordinated information he needs, and to provide him with a rational, analytic basis for decision-making about the utilization of all forms of science and technology. At present, there is no recommended or generally accepted curriculum for educating public administrators for managing science and technology. The academic community in Public Administration, with assistance from the information science and management science communities, should form a committee to recommend a curriculum in this area.

- 14717.** Lechner, J. A., **Effective statistical tests for detection models**, *Proc. 30th Military Operations Research Symp., Ft. Lee, Va., Dec. 12-14, 1972*, pp. 1-26 (1972).

Key words: detection models; detections; generalized Poisson process; statistical tests; testing.

A "Detection Model" is an entity which calculates an instantaneous probability of detection of a "target" by a "hunter," from the values of variables which describe the environment and the actions of both hunter and target, including past history, if appropriate. Given such a model, and a succession of non-identical trials which terminate at detection or after a given period of time (whichever occurs first), it is desired to test the adequacy of the model.

An approach to this problem is presented, based upon recognizing the set of trials as a nonhomogeneous Poisson process. Ways to improve the "power" of such tests by rearranging various segments of the trials are presented and discussed, including proper implementation of the tests using a digital computer. Extensions to the problem of improving the model and/or devising a new model are briefly discussed.

- 14718.** Kirchhoff, W. H., **Determination of force fields by analysis of centrifugal distortion in microwave spectra**, (Proc. Conf. Critical Evaluation of Chemical and Physical Structural Information, Dartmouth College, Hanover, N.H., June 24-29, 1973), Paper in *Critical Evaluation of Chemical and Physical Structural Information*, D. R. Lide, Jr., and M. A. Paul, Eds., pp. 312-322 (1974).

Key words: centrifugal distortion; force field; microwave spectra.

This paper describes the accuracy of molecular force fields derived from centrifugal distortion constants. Only bent, symmetric, triatomic molecules are discussed. The discussion deals primarily with the discrimination between the effects of measurement and model errors. The accuracy of the force field is judged by calculating from the force constants of the harmonic, fundamental vibrational frequencies and comparing these with the harmonic frequencies obtained from the infrared spectrum. This comparison, in turn, is measured against measurement errors arising from a statistical analysis of the microwave spectra. The particular molecular species for which such an analysis has been performed are SO<sub>2</sub>, OF<sub>2</sub>, SiF<sub>2</sub>, O<sub>3</sub>, OCl<sub>2</sub>, CF<sub>2</sub>, and SF<sub>2</sub>.

- 14719.** Leasure, W. A., Jr., Mathews, D. E., Rinkinen, W. J., **Truck Noise 1-A: Noise evaluation tests of military truck tires**, *Report No. DOT-TST-74-21*, 53 pages (Available as PB234-348 from the National Technical Information Service, Springfield, Va. 22161, Feb. 1974).

Key words: acoustics; noise measurement; noise(sound); tire noise; transportation noise; trucks.

This report presents the A-weighted sound level and one-third octave band spectral data resulting from a study conducted to characterize the noise generated by military truck tires. The study was conducted by the National Bureau of Standards in cooperation with the U.S. Department of Transportation under the sponsorship of the U.S. Army Tank-Automotive Command. The data base established will allow for comparison of the tire noise generated by military and commercial truck tires.

The study investigated the influence of load and speed on the noise generated by tires with four different tread designs: the standard Army tire, a retread of Army design and commercial tires with rib and cross-bar type tread patterns. Army and commercial trucks were utilized as test vehicles.

In addition, the report includes a discussion of the measurement and analysis techniques utilized for the establishment of this data base.



## 5. LISTING OF NBS PAPERS BY MAJOR SUBJECT AREA

This section provides a listing of 1974 papers organized by primary subject matter. It permits users of this catalog to scan the Bureau's output by major subject category. The user should bear in mind that a paper is listed once by major subject even though it might well contain other secondary subject matters of interest. The key-word index permits the reader to determine the overall context of a paper, and provides an excellent secondary reference source.

The categories currently in use for classifying NBS publications are listed below and are followed by a listing of each paper by category. Full citations (including key-words and abstracts) will be found under the appropriate publication series, which is included in the paper title. Also of use will be the key-word index (mentioned above) and the author index. See Section 6 for information on their organization and use.

### Acoustics and Sound

- Monogr. 142. **The measurement of noise performance factors: A metrology guide**, M. G. Arthur, Nat. Bur. Stand. (U.S.), Monogr. 142, 202 pages (June 1974) SD Catalog No. C13.44:142.
- TN651. **Scattering-matrix description and near-field measurements of electroacoustic transducers**, D. M. Kerns, Nat. Bur. Stand. (U.S.), Tech. Note 651, 40 pages (Mar. 1974) SD Catalog No. C13.46:651.
- TN841. **Review of reverberant sound power measurement standard and recommendations for further research**, Nat. Bur. Stand. (U.S.), Tech. Note 841, 24 pages (Aug. 1974) SD Catalog No. C13.46:841.
- NBSIR 73-417. **Evaluation of commercial integrating-type noise exposure meters**, W. A. Leasure, Jr., R. L. Fisher, and M. A. Cadoff, 33 pages (Dec. 1973). Order from NTIS as COM 74-10477.
13814. Cook, R. K., **The use of modulated reverberation for measurement of absorption and sound power**, (Proc. 1973 National Noise Control Engineering Conf., Washington, D.C., Oct. 15-17, 1973), Paper in *Noise-Con 73 Proceedings*, D. R. Tree, Ed., pp. 303-308 (Institute of Noise Control Engineering, Noise/News, Poughkeepsie, N.Y., Oct. 1973).
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14719. Leasure, W. A., Jr., Mathews, D. E., Rinkinen, W. J., **Truck Noise 1-A: Noise evaluation tests of military truck tires**, *Report No. DOT-TST-74-21*, 53 pages (Available as PB234-348 from the National Technical Information Service, Springfield, Va. 22161, Feb. 1974).

### Analytical Chemistry

- An improved procedure for synthesis of DL-4-hydroxy-3-methoxymandelic acid (DL-"vanillyl"-mandelic acid, VMA)**, A. J. Fatiadi and R. Schaffer, *J. Res. Nat. Bur. Stand. (U.S.)*, **78A** (Phys. and Chem.), No. 3, 411-412 (May-June 1974).
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## 6. INDEXES

### 6.1 HOW TO USE THE INDEXES

In addition to the usual author index, a subject index is provided in the form of a permuted key word index. In this type of index the key words in each publication or paper are arranged by shifting each group of key words along the horizontal printing line so that each key word in turn has an opportunity to appear alphabetically. The user is

thus able to locate papers of interest to him through the subject-related words he finds in the key word index.

The index symbols used in the author and key word indexes are explained in the following three tables. These tables also give the pages on which the abstracts of the various publication series begin.

Table A. Symbols for the Periodicals

| NBS Journal<br>of Research | Index Symbol |      |       | Issue Date             | Page<br>Number |
|----------------------------|--------------|------|-------|------------------------|----------------|
|                            | Vol.         | Sec. | No.   |                        |                |
| Section A                  | J78          | A    | 1     | January-February 1974  | 23             |
|                            | J78          | A    | 2     | March-April 1974       | 24             |
|                            | J78          | A    | 3     | May-June 1974          | 25             |
|                            | J78          | A    | 4     | July-August 1974       | 27             |
|                            | J78          | A    | 5     | September-October 1974 | 28             |
|                            | J78          | A    | 6     | November-December 1974 | 29             |
| Section B                  | J78          | B    | 1     | January-March 1974     | 30             |
|                            | J78          | B    | 2     | April-June 1974        | 30             |
|                            | J78          | B    | 3 & 4 | July-September 1974    | 31             |
|                            | J78          | B    | 3     | October-December       | 32             |

| DIMENSIONS/NBS | Index Symbol |     | Issue Date     | Page<br>Number |
|----------------|--------------|-----|----------------|----------------|
|                | Vol.         | No. |                |                |
| DIM            | 58           | 1   | January 1974   | 33             |
| DIM            | 58           | 2   | February 1974  | 33             |
| DIM            | 58           | 3   | March 1974     | 33             |
| DIM            | 58           | 4   | April 1974     | 33             |
| DIM            | 58           | 5   | May 1974       | 33             |
| DIM            | 58           | 6   | June 1974      | 34             |
| DIM            | 58           | 7   | July 1974      | 34             |
| DIM            | 58           | 8   | August 1974    | 34             |
| DIM            | 58           | 9   | September 1974 | 34             |
| DIM            | 58           | 10  | October 1974   | 35             |
| DIM            | 58           | 11  | November 1974  | 35             |
| DIM            | 58           | 12  | December 1974  | 35             |



Table B. Symbols for the Nonperiodicals

| NBS Nonperiodical Series                 | Index Symbol | Page Number |
|------------------------------------------|--------------|-------------|
| Monographs                               | Monogr.      | 47          |
| Handbooks                                | H            | 49          |
| Special Publications                     | SP           | 50          |
| Applied Mathematics Series               | AMS          | 77          |
| National Standard Reference Data Series  | NSRDS        | 77          |
| Building Science Series                  | BSS          | 78          |
| Federal Information Processing Standards | FIPS PUBS    | 83          |
| Product Standards                        | PS           | 84          |
| Technical Notes                          | TN           | 85          |
| Consumer Information Series              | CIS          | 95          |
| NBS Interagency Reports                  | NBSIR        | 96          |

Table C. Symbols for the Papers Published by Others (1973)

| NBS Papers Published by Others<br>(1973)                          | Index Symbol                               | Page Number |
|-------------------------------------------------------------------|--------------------------------------------|-------------|
| Professional Journals, Books,<br>Book Chapters, Proceedings, etc. | Five-Digit numbers, 13804<br>through 14719 | 119         |



## 6.2. AUTHOR INDEX

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- Crack propagation; cyclic fatigue; failure prediction; high temperature; static fatigue; ceramics; crack healing; *NBSIR 74-442*.
- Crack propagation; delayed failure; fracture; proof testing; Weibull analysis; ceramics; *NBSIR 74-486*.
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- Crack propagation; fracture; fracture mechanics; glass; strength; *14579*.
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- Critical data, transition metal oxides; crystal structure transformations; electronic properties; magnetic properties; phase equilibria; phase transitions; *NSRDS-NBS49*.
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- Critical evaluation; data; NSRDS; physical chemistry; reference data; status report; compilation; *13903*.
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- Critical evaluation; gases; organic compounds; rate constants; atomic oxygen; chemical kinetics; compilation; *J. Phys. Chem. Ref. Data 2*, No. 3, 467-518 (1973).
- Critical evaluation of data; gases; thermal conductivity; *14369*.
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- Critical opalescence; critical point; critical-point phase transitions; critical anomalies; *I4644*.
- Critical phenomena; critical region of gases; equation of state; parametric equation; scaling laws; carbon dioxide; *I4677*.
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- Critical point; density; enthalpy; entropy; equation of state; heat capacity; ideal gas properties; latent heat; nitrogen; second virial coefficient; vapor pressure; velocity of sound; critically evaluated data; *J. Phys. Chem. Ref. Data 2*, No. 4, 757-922 (1973).
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- Critical review; emission spectra; intermetallic compounds; metals; soft x-ray; spectra; alloys; *J. Phys. Chem. Ref. Data 2*, No. 2, 411-426 (1973).
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- Critically evaluated data; crystal structures; elements; high pressure; melting curves; phase diagrams; polymorphism; *J. Phys. Chem. Ref. Data 3*, No. 3, 781-824 (1974).
- Critically evaluated data; data compilation; elements; reference data; thermal conductivity; transport properties; conductivity; *J. Phys. Chem. Ref. Data 1*, No. 2, 279-421 (1972).
- Critically evaluated data; Debye temperature ( $\theta$ ); electronic coefficient of heat capacity ( $\gamma$ ); enthalpy; entropy; Gibbs energy; heat capacity; iridium; osmium, palladium; platinum; *J. Phys. Chem. Ref. Data 3*, No. 1, 163-209 (1974).
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- Critically evaluated data; dilute polyatomic gas; kinetic theory of polyatomic molecules; *m*-6-8 potential; nitrogen; nonspherical interactions; oxygen; second virial coefficient; *J. Phys. Chem. Ref. Data 2*, No. 4, 735-756 (1973).
- Critically evaluated data; enthalpy; enthalpy function; enthalpy of formation; entropy; equilibrium constant of formation; ethane; Gibbs energy function; Gibbs energy of formation; heat capacity; *J. Phys. Chem. Ref. Data 2*, No. 2, 427-437 (1973).
- Critically evaluated data; enthalpy; entropy; equilibrium constant of formation; free energy of formation; Gibbs energy function; heat capacity; heat of formation; thermochemical tables; *J. Phys. Chem. Ref. Data 3*, No. 2, 311-480 (1974).
- Critically evaluated data; excess Gibbs energy for electrolytes; osmotic coefficients; activity coefficients; *J. Phys. Chem. Ref. Data 1*, No. 4, 1047-1100 (1972).
- Critically evaluated data; fluorine; kinetic theory; modified Enskog theory; thermal conductivity; viscosity; *J. Phys. Chem. Ref. Data 1*, No. 4, 1101-1114 (1972).
- Critically evaluated data; high pressure; high pressure phase changes; pressure measurement; calibration of pressure scales; *J. Phys. Chem. Ref. Data 1*, No. 3, 773-836 (1972).
- Critically evaluated data; iodates; iodites; perbromates; perchlorates; periodates; thermal decomposition; thermodynamic functions; bromates; bromites; chlorates; chlorites; *J. Phys. Chem. Ref. Data 3*, No. 2, 481-526 (1974).
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Data elements and codes; data processing systems; Federal Information Processing Standards; management information systems; International Organization for Standardization; standards; U.S. Government; American National Standards; computers; *FIPS PUB 12-2*.

Data elements and representations; data processing systems; Federal Information Processing Standards; management information systems; standards; U.S. Government; computers; *FIPS PUB 28*.

Data entry; document labeling; labeling; listing; man machine interface; MICR printing; remittance processing; remittance register; audit trail; check endorsement; check handling; *NBSIR 74-577-1*.

Data entry; document labeling; labeling; listing; man machine interface; MICR printing; remittance processing; remittance register; audit trail; check endorsement; check handling; *NBSIR 74-577-2*.

Data evaluation; energy transfer; gas phase; high temperature air chemistry; ion-molecule reactions; optical absorption cross sections; photochemistry; quantum yield; rate constants; atmospheric chemistry; chemical kinetics; *NBSIR 74-430*.

Data evaluation; evaporation coefficients; phase change; condensation coefficients; *J. Phys. Chem. Ref. Data 1*, No. 1, 135-146 (1972).

Data evaluation; gas phase; optical; rate constants; stratospheric chemistry; absorption cross sections; atmospheric chemistry; chemical kinetics; chlorine; chlorine dioxide; chlorine monoxide; *NBSIR 74-516*.

Data evaluation; gas phase reactions; optical absorption coefficients; photochemistry; quantum yields; rate constants; atmospheric chemistry; chemical kinetics; *J. Phys. Chem. Ref. Data 2*, No. 2, 267-311 (1973).

Data evaluation; homogeneous nucleation; phase change; critical supersaturation; *J. Phys. Chem. Ref. Data 1*, No. 1, 119-133 (1972).

Data handling; data storage and retrieval; information handling technology; information processing; intellectual process; patent examination; Patent Office; patent storage; production statistics; administrative operations; *TN834*.

Data interchange; information processing; standards; codes; compatibility; computers; *14330*.

Data management; data processing; Federal Information Processing Standards; information interchange; information processing; information systems; American National Standards; American National Standards Institute; data; data base



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- Data management; information retrieval; information services; interactive system; query language; software selection; text processing; bibliographic systems; computer programs; computer systems; data base; *TN819*.
- Data processing; Federal Information Processing Standards Publication; representations and codes; Standard Metropolitan Statistical Areas; computers; *FIPS PUB 8-4*.
- Data processing; Federal Information Processing Standards; geography; information processing standards; information systems; representations and codes; standards; statistical data; ADP standards; computers; data elements and codes; *FIPS PUB 10-1*.
- Data processing; Federal Information Processing Standard; information interchange; information processing; programming language; software; COBOL; compilers; *FIPS PUB 29*.
- Data processing; Federal Information Processing Standards; information processing; computer programs; computers; computer software; *FIPS PUB 30*.
- Data processing; Federal Information Processing Standards; information interchange; information processing; information systems; American National Standards; American National Standards Institute; data; data base systems; data elements; *NBSIR 74-466*.
- Data processing; Federal Information Processing Standard; information interchange; information processing; programming language; software; COBOL; *NBSIR 74-487*.
- Data processing systems; Federal Information Processing Standards; management information systems; International Organization for Standardization; standards; U.S. Government; American National Standards; computers; data elements and codes; *FIPS PUB 12-2*.
- Data processing systems; Federal Information Processing Standards; management information systems; standards; U.S. Government; computers; data elements and representations; *FIPS PUB 28*.
- Data reporting procedures; Intergovernmental Oceanographic Commission (IOC); marine pollution (petroleum) monitoring; Maritime Administration (MarAd); National Bureau of Standards (NBS); *SP409*.
- Data sources; mechanical properties; metals; commercial alloys; *SP396-1*.
- Data storage and retrieval; information handling technology; information processing; intellectual process; patent examination; Patent Office; patent storage; production statistics; administrative operations; data handling; *TN834*.
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- Death; draperies; FFACTS; fires; flammable fabrics; houses; standards; statistical data; burns; case histories; curtains; *NBSIR 73-234*.
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Density; electrical conductance; molten salt mixtures; nitrates; nitrites; standard reference data; surface tension; viscosity; data compilation; *J. Phys. Chem. Ref. Data* 1, No. 3, 581-746 (1972).

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- Ground vibrational state; microwave spectrum of hexafluoropropene; rotational constants; *I3909*.
- Group algebras; irreducible representations; matrix functions; central idempotents; *I3996*.
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- MUMPS; protein adsorption; thermometry; blood banking; bone cement; clinical lab; clinical SRM's; dental research; *DIM/NBS 58*, No. 5, 97-120 (1974).
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- Heat capacity; liquid; saturated liquid; specific heat; methane; constant volume; *J.78A No. 3*, 401-410 (1974).
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- Heat of crystallization; heat of formation; polymer; standard reference polymer; enthalpy; heat of combustion; *J.78A No. 5*, 611-616 (1974).
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- Heat of formation; selected values; CHNOPS compounds; heat of combustion; *J. Phys. Chem. Ref. Data 1*, No. 2, 221-277 (1972).
- Heat of formation; thermochemical tables; critically evaluated data; enthalpy; entropy; equilibrium constant of formation; free energy of formation; Gibbs energy function; heat capacity; *J. Phys. Chem. Ref. Data 3*, No. 2, 311-480 (1974).
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Measurement instrumentation; spectral density; time-dependent spectral density; amplitude probability distribution; coal mine noise; digital electromagnetic communications; electromagnetic interference; electromagnetic noise; Fast Fourier Transform; *NBSIR 74-390*.

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- 58, No. 12, 265-288 (1974).
- Measurement services; standardization; AID; assistance; economics; foreign relations; industrializing nations; LDC's; *NBSIR 74-550*.
- Measurement system; photometry; professional societies; radiometry; standards; *TN594-6*.
- Measurement system; weights and measures; Alaskan baseline study; consumer goods; door security; ferrite measurement; health hazards; industry incentives; international program; law enforcement; *DIM/NBS 58*, No. 2, 25-48 (1974).
- Measurement system description; phase noise; spectral density; terminology standards; Allan variance; frequency stability measurements; *NBSIR 74-396*.
- Measurement technique; Si; tungsten wires;  $\text{CaF}_2$ ; density; *J.78A No. 1*, 9-13 (1974).
- Measurement techniques; performance requirements; building research; building standards; *I4564*.
- Measuring energy utilization; miners (communications); atomic timekeeping; building technology; disaster studies; energy-saving building construction; energy squeeze; insulation; *DIM/NBS 58*, No. 3, 49-72 (1974).
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- Mechanical failure; microwaves; oscillator calibration; big G; bolometer calibration; earthquake prediction; frequency standard systems; heat-pipe ovens; Hoover; liquefied natural gas; magnetometer; *DIM/NBS 58*, No. 8, 169-192 (1974).
- Mechanical properties; metals; biomaterials; corrosion; implant materials; *NBSIR 73-420*.
- Mechanical properties; metals; commercial alloys; data sources; *SP396-1*.
- Mechanical properties; particulate composites; shear modulus; theory of elasticity; bulk modulus; composite materials; elastic constants; filled polymers; *J.78A No. 3*, 355-361 (1974).
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- Mechanical properties; rheology; scalar-potential; strain-energy; thermodynamics; viscoelasticity; constitutive equation; continuum mechanics; elasticity; isotropy; material symmetry; *I4689*.
- Mechanical properties; stress corrosion; ultimate strength; brittle material; cleavage; deformation; fracture; hydrogen embrittlement; *I4476*.
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- Melting curves; phase diagrams; polymorphism; critically evaluated data; crystal structures; element ; high pressure; *J. Phys. Chem. Ref. Data 3*, No. 3, 781-824 (1974).
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Sample preparation; silicon characterization; spreading resistance; surface effects; automated resistivity measurements; calibration; germanium characterization; *SP400-10*, pp. 145-154.

Sample pressure; thermal neutron flux; threshold foil; cadmium ratio; fast neutron flux; neutron activation analysis; *I4083*.

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Sampling; standards; flammable fabrics; product safety; *SP411*, pp. 16-19.

Sampling; transition time; mercury switch; oscilloscope; picosecond; pulse; random sampling; risetime; *I4262*.

Sampling methods; World Meteorological Organization (WMO); analytical methods; data reporting procedures; Intergovernmental Oceanographic Commission (IOC); marine pollution (petroleum) monitoring; Maritime Administration (MarAd); *SP409*.

Sampling plans; upholstered furniture; blankets; children's sleepwear; fabric fires; fabric flammability standards; FFacts; fire injuries; flammable fabrics; flammability standards priorities; garment flammability; garments; *I3972*.

Sandia bridge; scattering; S-parameters; transistors; vector voltmeter; delay time; electronics; high-frequency probes; *NBSIR 73-152*.

Sandwich specimen; stress-strain curves; tensile properties; aluminum alloy; boron/epoxy; co-cure; composite materials; fabrication process; load-deformation characteristics; residual stress; rule of mixtures; *TN812*.

Sanitary DWV systems; secondary ventilation; testing plumbing systems; vents for plumbing; hydraulic criteria for plumbing; hydraulic test loads; plumbing-vent sizing; reduced-size vents; *BSS49*.

Sapphire; sodium chloride; electron microscopy; fracture; mechanical properties; plastic deformation; *NBSIR 73-297*.

Sapphire; strength; transmission electron microscopy; alumina; crack growth; critical stress intensity factor; fracture; plastic deformation; *I3853*.

Satellite altitudes; atmosphere; auroral electrons; bremsstrahlung; energy spectra; Monte Carlo calculation; *I4452*.

Satellite research centers; advisers to inventors; deferred examinations; innovation; invention; mechanized searching; patent litigation; Patent Office; patent system reform; petty patents; *SP388*, pp. 111-115.

Satellite T/F dissemination; short-term stability; SI Units; TAI; television T/F dissemination; thallium beam standards; time; time dispersion; time domain; time/frequency statistics; time scale algorithm; time scales; "unified standard"; URSI; *Monogr. 140*.

Satellite time; sprinkler systems; aircraft failure; Copernicus; corrosion; length standard; lens calibration; police helmets; *DIM/NBS 58*, No. 4, 74-96 (1974).

Satellite timing; synchronous satellite; clock synchronization; one-way time transfer; *NBSIR 73-348*.

Satellites; time; frequency; *I4060*.

Saturated absorption; CO<sub>2</sub> and He-Ne laser frequency; methane; *I4321*.

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Saturated absorption; wavelengths; iodine stabilized lasers; krypton; pressure broadening; pressure shifts; *I4201*.

Saturated absorption spectroscopy; ultrahigh resolution; laser spectroscopy; methane; molecular hyperfine spectra; *I4673*.

Saturated absorption stabilizer; strainmeter; geophysics; interferometry; *I4581*.

Saturated liquid; specific heat; methane; constant volume; heat capacity; liquid; *J.78A No. 3*, 401-410 (1974).



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- Second virial coefficient; vapor pressure; velocity of sound; critically evaluated data; critical point; density; enthalpy; entropy; equation of state; heat capacity; ideal gas properties; latent heat; nitrogen; *J. Phys. Chem. Ref. Data 2*, No. 4, 757-922 (1973).
- Secondary standard; combustion; enthalpy; formation; heat; isomerization; *J.78A No. 6*, 683-689 (1974).
- Secondary ventilation; testing plumbing systems; vents for plumbing; hydraulic criteria for plumbing; hydraulic test loads; plumbing-vent sizing; reduced-size vents; sanitary DWV systems; *BSS49*.
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- Selection rules; tetrahedral point group; group theory; methane; rovibronic symmetry species; *14138*.
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- Semiconductors; cadmium telluride; frequency dispersion; lattice dynamics; neutron inelastic scattering; phonon dispersion relation; *I4375*.
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- Silicon; spreading resistance; crystal growth; Czochralski; Fourier transform; microsegregation; resistivity characterization; *SP400-10*, pp. 191-199.
- Silicon; spreading resistance; dopant concentration; dopant profiles; metal-semiconductor contacts; resistivity; semiconductor surface preparation; *SP400-10*.
- Silicon; spreading resistance; steel probe; topography; bevel; interferometer; jig; microcontacts; *SP400-10*, pp. 99-108.
- Silicon; spreading resistance; surface orientation; contact radius; correction factors; *SP400-10*, pp. 137-144.
- Silicon; spreading resistance; test patterns; thermal response; thermally stimulated capacitance; thermally stimulated current; thick film copper; voltage contrast mode; wire bonds; x-ray photoelectron spectroscopy; boron redistribution; collector resistor; doping profiles; *SP400-4*.
- Silicon; spreading resistance; test pattern; epilayer thickness; *SP400-10*, pp. 217-221.
- Silicon; surface photovoltage; carrier lifetime; gallium arsenide; gold-doped silicon; resistivity; *I4606*.
- Silicon; thermally stimulated measurements; defect centers; *p-n* junction; semiconductor characterization; *I4226*.
- Silicon; wire bonding; die bonding; hermeticity; integrated circuits; measurement methods; microelectronics; oxides; photolithography; process control; reliability; semiconductor devices; *SP400-3*.
- Silicon characterization; spreading resistance; surface effects; automated resistivity measurements; calibration; germanium characterization; sample preparation; *SP400-10*, pp. 145-154.
- Silicon doping profiles; spreading resistance measurement; surface damage; bevelling; diamond grinding; laser bevel angle measurement; layer thickness determination; materials; resistivity measurement; *SP400-10*, pp. 123-136.
- Silicon monoxide; carbon monosulfide; carbon monoxide; interstellar molecules; microwave spectra; molecular parameters; radio astronomy; rotational transitions; *J. Phys. Chem. Ref. Data 3*, No. 1, 245-257 (1974).
- Silicon nitride; slow crack growth; elevated temperatures; failure prediction; *I4278*.
- Silicon resistivity; spreading resistance techniques; dark field coring; MOS-CV techniques; PICTUREPHONE<sup>®</sup>; radial resistivity inhomogeneities; *SP400-10*, pp. 179-184.
- Silicon single crystals; spreading resistance measurements; swirls; oxygen in silicon; *SP400-10*, pp. 185-190.
- Silicosis; x-ray diffraction; analytical methods; industrial hygiene; quartz; *I3975*.
- Silver; surface diffusion; thermomigration; alloy diffusion; copper; diffusion; electromigration; gold; grain boundary diffusion; impurity diffusion; liquid metal diffusion; *J. Phys. Chem. Ref. Data 3*, No. 2, 527-602 (1974).
- Silver; titanium; yields; aluminum; beryllium; carbon; copper; electron excitation; gold; *K* x-ray beams; purities; *I4261*.
- Simulation; algorithms; least-squares; multilateration; position-location; ranges; *I4387*.
- Simulation; City IV; computer; Fortran; gaming; IBM 360/70; JCL; *NBSIR 73-112*.
- Simulation; computer; decision-making; games; learning; manual games; *SP395*.
- Simulation; simulation module; computer programs; computers; computer simulation; equations; mathematical foundations; mathematics; *NBSIR 74-556*.
- Simulation; social; city; computer; computer games; economic; government; metropolitan; *NBSIR 74-555*.
- Simulation; social; urban; city; computer; directors; economic; games; government; metropolitan; players; sectors; *NBSIR 73-108*.
- Simulation; social; urban; city; computer; directors; economic; games; government; metropolitan; players; sectors; *NBSIR 73-110*.
- Simulation; social; urban; city; computer; director's; economic; games; government; metropolitan players; sectors; *NBSIR 73-113*.
- Simulation; social; urban; city; computer; directors; economic; games; government; metropolitan; players; sectors; *NBSIR 73-114*.
- Simulation; social urban; city; computer; director's; economic; games; government; metropolitan players; sectors; *NBSIR 73-109*.
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- Simulation; thermal efficiency; buildings; conservation; energy; energy sources; measurement; *I4669*.
- Simulation module; computer programs; computers; computer simulation; equations; mathematical foundations; mathematics; simulation; *NBSIR 74-556*.
- Simulation of clock performance; atomic clock; atomic clock modeling; atomic clock noise; atomic clock performance; atomic time scale accuracy; comparison of atomic time scales; comparison of frequency standards; frequency calibration; frequency drift; *I3989*.
- Simulation of computer systems; software monitors; systems design and evaluation; time-sharing systems evaluation; computer evaluation; computer performance; computer scheduling; hardware monitors; *SP401*.
- Simulator; computer system; FORTRAN IV; operating system; resource allocation strategies; *I4623*.
- Single axis rotator; site model; Smoluchowski's equation; dielectric loss; relaxation; *I4646*.
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- Single crystal; vibration amplitudes; hydrogen diffusion; hydrogen in tantalum; interstitial sites; neutron scattering; quasielastic scattering; residence time; *I4368*.
- Single crystal; Voigt-Reuss-Hill; Debye temperature; elastic constants; lattice-vibrational properties; polycrystal; *I3987*.
- Single crystal; x-ray diffraction; beta tricalcium phosphates; cation vacancies; positional disorder; *I4540*.
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- Single crystal x-ray diffraction; calcium phosphate; centered hydrogen bonds; hydrogen bonding; single crystal neutron diffraction; *I3874*.
- Single crystal x-ray diffraction; structural relationships; tetracalcium phosphate; twinning; crystal structure; hydroxyapatite; *I4263*.
- Single crystals; cubic potassium antimonate; flux synthesis; impurity stabilization; potassium antimonate; potassium fluoride-antimony oxide; *I4390*.
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- Single-crystal elastic coefficients; Young's modulus; bulk modulus; compressibility; copper; elastic constants; Poisson's ratio; shear modulus; *J. Phys. Chem. Ref. Data 3*, No. 4, 897-936 (1974).
- Single-crystal surface; surface; surface finish; surface profile; microscope; microtopography; *14523*.
- Single-machine scheduling; job scheduling; minimizing maximum lateness; minimizing total delay; multimachine scheduling; scheduling; scheduling algorithms; *14313*.
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- Sintering; surface diffusion; thermo-migration; copper; diffusion; electromigration; liquid copper diffusion; nuclear magnetic resonance and diffusion; pressure effects on diffusion; self-diffusion; *J. Phys. Chem. Ref. Data 2*, No. 3, 643-656 (1973).
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- Smoke; carbon monoxide; electrostatic precipitation; particulate mass; scanning electron microscope; *SP411*, pp. 165-177.
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- Smoke and gas fatalities; waster; water; computer vote; cost-sharing; cryogenic data; earthquake; energy; grain alcohol; measurement science; pollution; screw threads; *DIM/NBS 58*, No. 12, 265-288 (1974).
- Smoke control; building fires; design; evacuation; fire alarms; fire protection; fire resistance; fire safety; fire spread; fire statistics; fire suppression; high rise buildings; ignition source; life safety; refuge areas; *14229*.
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- Social; urban; city; computer; directors; economic; games; government; metropolitan; players; sectors; simulation; *NBSIR 73-108*.
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- System  $\text{Ca(OH)}_2 - \text{H}_3\text{PO}_4 - \text{H}_2\text{O} - \text{NaCl}$ ; brushite;  $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ ;  $\text{NaHPO}_4^-$  ion pair; solubility product; *J.78A No. 6, 675-681 (1974)*.
- System design; architecture; design; hospital design; medical facilities; military construction; new generation military hospital; *BSS54*, pp. 1-12.
- System errors; system performance; theorem-proving; compiler; computer network; documentation; dynamic software analysis; interpreter; quality control; software testing; software verification; static software analysis; structured programming; *TN800*.
- System  $\text{NaCl-AlCl}_3$ ; immiscibility;  $\text{NaAlCl}_4$ ; phase equilibrium; system  $\text{AlCl}_3\text{-NaCl}$ ; *J.78A No. 4, 505-507 (1974)*.
- System performance; theorem-proving; compiler; computer network; documentation; dynamic software analysis; interpreter; quality control; software testing; software verification; static software analysis; structured programming; system errors; *TN800*.
- Systematic trends; atomic oscillator strengths; perturbation theory; regularities; *13940*.
- Systems analysis; Alexandria; fire department; location; operations research; resource allocation; simulation; *TN782*.
- Systems, building; office buildings; performance criteria; *14101*.
- Systems design and evaluation; time-sharing systems evaluation; computer evaluation; computer performance; computer scheduling; hardware monitors; simulation of computer systems; software monitors; *SP401*.

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Ta target; thermoluminescent detectors; 30 and 57.4 MeV electrons; angular distribution; depth-dose; photon energy; *14040*.



Table; torsional crystal; viscosity; comparisons; graph; methane; saturated liquid; *I4234*.

Tables; activation energies; evaluation; gaseous reactions; radical reactions; rate constants; review; sulfur chemistry; *J. Phys. Chem. Ref. Data* 2, No. 1, 25-84 (1973).

Tables; temperature; uncertainties; volume; argon; compressed liquid; density; density ratios; liquid; nitrogen, oxygen; parahydrogen; pressure; saturated liquid; *TN361. (Revised). Metric Supplement*.

Tables; thermal conductivity coefficient; transport property; viscosity coefficient; xenon; argon; correlation; critical data evaluation; critical point; dense gas and liquid; excess transport property functions; *J. Phys. Chem. Ref. Data* 3, No. 4, 979-1018 (1974).

TAI; television T/F dissemination; thallium beam standards; time; time dispersion; time domain; time/frequency statistics; time scale algorithm; time scales; "unified standard"; URSI; USA standard time zones; UTC (NBS); UTC (USNO); accuracy; *Monogr. 140*.

Tall buildings; accident occurrence; building; gas explosion; hazards; progressive collapse; *I4105*.

Tall buildings; turbulence; wind (meteorology); acceleration; aerodynamics; building (codes); deflection; dynamic structural analysis; pressure; spectra; structural engineering; *I4534*.

Tall buildings; wind effects; wind loads; wind tunnel; climatological data; meteorology; *I4104*.

Tall buildings; wind profiles; boundary layer; hurricanes; loads (forces); natural disasters; structural analysis; *I4639*.

Tantalates; alkali ions; ionic conductors; niobates; *I4185*.

Tantalum; temperature measurements; tungsten-rhenium alloys; beryllium oxide; emf drift; sheathed thermocouples; *I4377*.

Tantalum; tensile properties; evaluation; high temperature tests; molybdenum; plastic flow; Poisson ratio; refractory metals; strain hardening; strain rate; stress strain diagrams; *I3819*.

Tape; temperature; tension; graduation; length; scale; *NBSIR 74-451*.

Targets; thick targets; electrons; MeV electrons; *I4572*.

Task force on automation; automation of library operations; Federal Library Committee; field libraries; FLC; library automation; *I4614*.

Task group collaboration; computer network; interpersonal communications; *I4117*.

TCNQ complexes; electron transport; magnetic properties; metallic; *I3959*.

TCNQ compounds; magnetic susceptibility; organic conductors; paramagnetism; *I4350*.

Technical innovations; antitechnical crisis; industrial laboratory; industrial research; scientist-inventor; *SP388*, pp. 159-164.

Technical requirements; technology; universal product coding; weights and measures; administration; automated checkstand systems; Conference; consumers; laws and regulations; metrication; open dating; procedures; *SP391*.

Techniques; ceramics; failure prediction; fracture mechanics; materials development; *I4260*.

Techniques; computer simulation; live and fire loads; occupancy; stochastic predictive models; survey; *I4102*.

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Technological innovation; business management; inventor-entrepreneur; national priorities; national problems; *SP388*, pp. 31-36.

Technological innovation; Experimental Technology Incentives Program; inventors; National Bureau of Standards; Office of Invention and Innovation; *SP388*, pp. 131-135.

Technological innovation; technology transfer programs; government patent policy; government R. & D.; technology enhancement efforts; *SP388*, pp. 5-6.

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Technology; antitrust doctrine; employed inventors; entrepreneurship; innovation; invention; needs of society; new enterprises; Patent Office; patent system; technological policy making; *SP388*.

Technology; universal product coding; weights and measures; administration; automated checkstand systems; Conference; consumers; laws and regulations; metrication; open dating; procedures; technical requirements; *SP391*.

Technology assessment; engineering education; solid waste disposal; *I3974*.

Technology assessment program; experimental incentives programs; Federal incentives; technological policy making; *SP388*, pp. 17-20.

Technology enhancement efforts; technological innovation; technology transfer programs; government patent policy; government R. & D.; *SP388*, pp. 5-6.

Technology implementation; wind effects; wind loads; codes and standards; information transfer; low-rise buildings; pressure transducers; socio-economic; structural design; *BSS56*.

Technology transfer; administration; education; information; management; public; science; *I4716*.

Technology transfer programs; government patent policy; government R. & D.; technology enhancement efforts; technological innovation; *SP388*, pp. 5-6.

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Teleprocessing; terminology; vocabulary; computer networks; glossary; telecommunications; *TN803*.

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Temperature; acoustical thermometry;  $\gamma$ -ray anisotropy thermometry; noise thermometry; nuclear magnetic resonance; nuclear quadrupole resonance; paramagnetism; superconductivity; *TN830*.

Temperature; closure seal; electrical feedthrough; high pressure; hydrostatic; NMR; *I4078*.

Temperature; fixed points; paramagnetism; superconductivity; *I4178*.

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Temperature scale; thermodynamic consistency; ammonia; heat capacity; ideal gas; PVT data; PVT surface; *14678*.

Temperature standards; thermocouples; thermometry; base metal alloys; noble metal alloys; temperature scale; *Monogr. 125*.

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- Testing (wire bond); ultrasonic bonding; wire bond; bonding; degradation (wire bond); discrete devices; electrical interconnection; fabrication (wire bond); failure (wire bond); hybrid circuits; integrated circuits; microelectronics; reliability; *SP400-2*.
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- Textiles; thermal analysis; calorimetry; cellulose; flames; flammable gases; nylon; oxidation reactions; oxygen index; phosphorus; polyester; polymer substrates; pyrolysis-gas chromatography; *SP411*, pp. 37-49.
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- Th II spectrum; thorium; wavelengths of Th II; energy levels of Th II;  $g$ -values of Th II; spectrum of Th II; *J.78A No. 2*, 163-246 (1974).
- Thallium beam standards; time; time dispersion; time domain; time/frequency statistics; time scale algorithm; time scales; "unified standard"; URSI; USA standard time zones; UTC (NBS); UTC (USNO); accuracy; Allan variance; atomic frequency standards; *Monogr. 140*.
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- Thermal coefficient of solubility; beta-tricalcium phosphate, preparation; solubility, solubility product, stoichiometry of; dissolution, thermodynamics of; ion pairs; singular points; solubility isotherms; *J.78A No. 6*, 667-674 (1974).
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- Thermal conductivity; thermophysical properties; transport properties; glass transition; heat transfer; Hevea rubber; *I4591*.
- Thermal conductivity; transport properties; conductivity; critically evaluated data; data compilation; elements; reference data; *J. Phys. Chem. Ref. Data* 1, No. 2, 279-421 (1972).
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- Thermal convection; x-ray topography; copper single crystals; crystal perfection; dislocations; fluid flow; *I3944*.
- Thermal decomposition; thermodynamics; inorganic oxyanions; *I3850*.
- Thermal decomposition; thermodynamic functions; nitrates; nitrites; *J. Phys. Chem. Ref. Data* 1, No. 3, 747-772 (1972).
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- Thermal decomposition; 1,1-difluoroethane; 1,1,1-trifluoroethane; elimination; fluoroethane; kinetics; single pulse shock tube; *I4199*.
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- Vibrational frequencies; fundamental frequencies; infrared spectra; polyatomic molecules; Raman spectra; *J. Phys. Chem. Ref. Data 2*, No. 1, 121-161 (1973).
- Vibrational frequencies; fundamental frequencies; infrared spectra; polyatomic molecules; Raman spectra; *J. Phys. Chem. Ref. Data 2*, No. 2, 225-256 (1973).
- Vibrational frequencies; fundamental frequencies; infrared spectra; polyatomic molecules; Raman spectra; *J. Phys. Chem. Ref. Data 3*, No. 1, 269-308 (1974).
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- Vinyl acetate-dibutyl maleate; vinyl acetate-ethylene; vinyl acetate-ethyl acrylate; vinyl acetate-2-ethyl-hexyl acrylate; vinyl chloride-acrylate; acrylic; alkyd modified latex paints; deep-tone latex paints; infrared spectroscopy; polyvinyl acetate; styrene-acrylate; *I3816*.
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- Viscoelasticity; constitutive equation; continuum mechanics; elasticity; isotropy; material symmetry; mechanical properties; rheology; scalar-potential; strain-energy; thermodynamics; *I4689*.
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- Viscosity; comparisons; graph; methane; saturated liquid; table; torsional crystal; *I4234*.
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- Viscosity; critically evaluated data; fluorine; kinetic theory; modified Enskog theory; thermal conductivity; *J. Phys. Chem. Ref. Data 1*, No. 4, 1101-1114 (1972).
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- Viscosity; glass; microstructure; phase separation; *I4494*.
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- Viscosity; volume; density; dielectric constant; enthalpy; entropy; equation of state; fixed points; heat transfer coefficients; index of refraction; Joule-Thomson; latent heat; melting point; nitrogen; Prandtl number; specific heat; speed of sound; surface tension; *TN648*.
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- Viscosity coefficient; xenon; argon; correlation; critical data evaluation; critical point; dense gas and liquid; excess transport property functions; krypton; nitrogen; oxygen; tables; *J. Phys. Chem. Ref. Data 3*, No. 4, 979-1018 (1974).
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- Viscosity standard; beam-bending; fiber-elongation; Fulcher equation; glass viscosity; standard reference material; viscosity; *J.78A No. 3*, 323-329 (1974).
- Visible; averaging sphere; deuterium arc lamp; fluorescent wavelength converter; grating; spectrophotometry; standard reference materials; ultraviolet; UV achromats; *J.78A No. 5*, 631-636 (1974).
- Visible molecular absorption; dye laser; intra-cavity absorption; iodine detection; laser quenching; trace absorption detection; *I3861*.
- Vision; bibliography; color; color codes; colorimetry; color measurement; spectrophotometry; *SP393*.
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- Voice privacy; intelligibility; LESL; NILECJ; performance standard; privacy; scramblers; speech quality; speech scramblers; survey; testing; *I4714*.



- Voigt-Reuss-Hill; Debye temperature; elastic constants; lattice-vibrational properties; polycrystal; single crystal; *13987*.
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- Voltage divider; asymptotic expansion; characteristic impedance; coaxial line; complimentary error function; conductor; cylindrical; dielectric; error; generator; lossy; microminiature; model; planar; propagation function; pulse; receiving end; skin effect; step response; *14347*.
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- Volume; argon; compressed liquid; density; density ratios; liquid; nitrogen, oxygen; parahydrogen; pressure; saturated liquid; tables; temperature; uncertainties; *TN361. (Revised). Metric Supplement*.
- Volume; density; dielectric constant; enthalpy; entropy; equation of state; fixed points; heat transfer coefficients; index of refraction; Joule-Thomson; latent heat; melting point; nitrogen; Prandtl number; specific heat; speed of sound; surface tension; *TN648*.
- Volume; weight; cost; cryogenic refrigerators; efficiency; *TN655*.
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- Volume of ball; asphericity correction; density; spherical harmonics; *J.78A No. 1, 41-48 (1974)*.
- Volume standard; density standard; hydrostatic weighing; perfect sphere; silicon; spherical interferometer; spherical volume; *J.78A No. 1, 13-40 (1974)*.
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- Warning lights and sirens; anthropometry; communications equipment; forensic science; Law Enforcement Standards Laboratory; LESL; performance standards; project plans; protective equipment; security equipment; standards; *NBSIR 74-529*.
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- Water; computer vote; cost-sharing; cryogenic data; earthquake; energy; grain alcohol; measurement science; pollution; screw threads; smoke and gas fatalities; waster; *DIM/NBS 58*, No. 12, 265-288 (1974).
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Wind tunnel; construction; design criteria; extreme winds; full-scale test buildings; housing; instrumentation; *NBSIR 74-582*.

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Xenon; argon; extraphotographic region; infrared emission spectra; intensities; neon; wavelengths; wavelength standards; wave numbers; *J. Phys. Chem. Ref. Data 2*, No. 3, 519-530 (1973).

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X-ray diffraction; beta tricalcium phosphates; cation vacancies; positional disorder; single crystal; *I4540*.

X-ray diffraction; crystal orientation; error propagation; Kossel lines; lattice spacings; stress-strain maps; *I4625*.

X-ray diffraction; crystal structure; integrated intensities; lattice constants; peak intensities, powder patterns; reference intensities; standard; *Monogr. 25, Section 11*.

X-ray diffraction microscopy;  $\text{Al}_2\text{O}_3$ ; Berg-Barrett; single crystal; skew reflection; vapor growth; *I3929*.

X-ray diffraction microscopy; dislocations;  $\text{KD}^*\text{P}$ ; Lang technique; solution grown; *I4156*.

X-ray fluorescence; automation; defraction; detectors; spectrometry; x-ray analysis; *I4384*.

X-ray fluorescence; x-ray spectrochemical analysis; calibration; empirical calibration; iron-nickel-chromium alloys; *I3911*.

X-ray fluorescence; x-ray spectrochemical analysis; calibration;



empirical calibration; high-temperature superalloys; 14218.  
 X-ray inelastic scattering; energy transfer; lithium; momentum transfer; x-ray absorption; 13983.  
 X-ray inelastic scattering; x-ray Raman scattering; Compton scattering; lithium; optical transitions; 14518.  
 X-ray measurements; standard reference materials; x-ray calibration; 14512.  
 X-ray photoelectron; chemical shifts; chemisorption; ESCA; nitric oxide; nitrogen; spectroscopy; 14271.  
 X-ray photoelectron; electronic structure; ESCA; hard magnets; magnetic materials; photoelectron spectroscopy; rare-earth magnets; 14231.  
 X-ray photoelectron spectra; argon, KCl, CH<sub>3</sub>Cl, SF<sub>6</sub>; L and K x-ray spectra; semi-Auger effect; 14400.  
 X-ray photoelectron spectroscopy; attenuation lengths; Auger-electron spectroscopy; inelastic cross sections; inelastic electron scattering at low energies; solids; 14453.  
 X-ray photoelectron spectroscopy; boron redistribution; collector resistor; doping profiles; effective masses; electrical properties; electron beam induced current mode electronics; epitaxial layer thickness; flying spot scanner; gold-doped silicon; hermeticity; SP400-4.  
 X-ray photoemission; aluminum; Auger-peak; secondary-electron energy distribution; 14547.  
 X-ray photoemission; aluminum; density of states; photoelectron energy distribution; 14541.  
 X-ray photoemission; electronic density of states; Pt; surface cleanliness; valence-band; 14136.  
 X-ray Raman scattering; Compton scattering; lithium; optical transitions; x-ray inelastic scattering; 14518.  
 X-ray scattering; dielectric loss; *n*-paraffins; phase transitions; J.78A No. 2, 131-141 (1974).  
 X-ray spectrochemical analysis; calibration; empirical calibration; iron-nickel-chromium alloys; x-ray fluorescence; 13911.  
 X-ray spectrochemical analysis; calibration; empirical calibration; high-temperature superalloys; x-ray fluorescence; 14218.  
 X-ray spectroscopy; corrections; electron probe microanalysis; quantitative analysis; 14328.  
 X-ray topography; copper single crystals; crystal perfection; dislocations; fluid flow; thermal convection; 13944.  
 X-ray, vacuum ultraviolet; radiation; source and electrons; synchrotron; 14636.  
 X-ray wavelengths; Avogadro's number; Compton wavelength; gamma-ray wavelength; lattice parameters; x-ray conversion factor; 14267.

## Y

Yb<sub>2</sub>O<sub>3</sub>; Gd<sub>2</sub>O<sub>3</sub>; fluorescence spectra; *M*<sub>4,5</sub> emission spectra; resonance radiation; 14239.  
 Y-factor; analysis; automation; noise figure; 14524.  
 Y-factor measurements; effective input noise temperature; measurement errors; noise factor; noise measurements; noise performance factors; noise temperature; Monogr. 142.  
 Yields; aluminum; beryllium; carbon; copper; electron excitation; gold; K x-ray beams; purities; silver; titanium; 14261.  
 YIG; ferrites; hyperfine fields; Mössbauer; Sb; 14459.  
 Youden diagram; collaborative reference programs; interlaboratory tests; test method evaluation; 13955.  
 Young's mixture rule; electrolytes; excess thermodynamic properties of mixtures; mixture; ternary solutions; thermodynamics; 14515.  
 Young's modulus; bulk modulus; compressibility; Debye temperature; elastic constant; Poisson's ratio; shear modulus; sound velocity; titanium alloys; 14172.  
 Young's modulus; bulk modulus; compressibility; elastic constant; Debye temperatures; iron; iron alloys; Lamé constants; nickel; nickel alloys; Poisson's ratio; shear modulus; J. Phys.

Chem. Ref. Data 2, No. 3, 531-618 (1973).

Young's modulus; bulk modulus; compressibility; copper; elastic constants; Poisson's ratio; shear modulus; single-crystal elastic coefficients; J. Phys. Chem. Ref. Data 3, No. 4, 897-936 (1974).  
 Young's modulus; composite; low temperature; Poisson's ratio; superconductor; thermal expansion; NBSIR 73-349.  
 Yttria-germania system; germania-yttria system; immiscibility; phase equilibrium; 14352.  
 Yttrium orthovanadate crystal damage; damage morphology; polishing compounds; spot-size dependence; surface defects; rutile crystal damage; SP414, pp. 193-199.  
 Yttrium-88; aluminum-26; bismuth-207; cobalt-60; niobium-94; radioactivity standardization; sodium-22; sum coincidence counting; 14299.

## Z

Zak; carbonium ion formation; cholestapolyenes; cholesterol; enylic cations; Liebermann-Burchard; oxidative reactions; reaction mechanisms; 14489.  
 Zak procedure; carbonium ions; cholesterol; enylic ions; isosbestic points; kinetics; reaction mechanisms; steroids; 14699.  
 Zeeman effect; atomic energy levels; atomic spectra; electron configurations; neutral cerium; 14408.  
 Zeeman effect; dense molecular clouds; magnetic field; Orion A; radio astronomy; sulfur monoxide; 14499.  
 Zero bias resistance; correction factor; crystallographic orientations; effective contact radius; interfaces; metal-semiconductor contacts; multilayered structure; piezoresistivity; resistivity; spreading resistance; stress; SP400-10, pp. 17-26.  
 Zero-g; materials processing; perfection; purity; space manufacturing; space processing; NBSIR 73-402.  
 Zinc selenide; CO<sub>2</sub> pulsed laser damage; damage threshold; laser windows; twin structure; SP414, pp. 85-92.  
 Zirconates; coal slag; electrical conductivity; high temperature; magnetohydrodynamics; 14081.  
 Zirconium; electrical resistivity; emittance; heat capacity; high-speed measurements; high temperature; thermodynamics; thermophysical properties; J.78A No. 4, 509-514 (1974).  
 Zn lamp; detection; fluorescence; H<sub>2</sub>O; SO<sub>2</sub>; 14380.  
 ZnSe; A/R coatings; damage thresholds; machined mirrors; SP414, pp. 53-58.  
 ZnSe; As<sub>2</sub>S<sub>3</sub>; laser coatings; laser reflectors; laser windows; pulsed CO<sub>2</sub> laser damage, ThF<sub>4</sub>; SP414, pp. 59-65.  
 ZnSe; CO<sub>2</sub> laser radiation; CW laser damage; infrared windows; KCl; NaCl; optical distortion; SP414, pp. 94-102.  
 0.694 μm; back-scattering; precatastrophic damage; pulse dynamics; reflection; ruby laser; surface damage; temporal pulse monitoring; transmission; SP414, pp. 179-189.  
 1-butene; abstraction reactions; addition reactions; atomic oxygen; reaction kinetics; 13977.  
 1-chloronaphthalene; 1,2,4-trichlorobenzene; fractionation; limiting viscosity number; linear polyethylene; Mark-Houwink; molecular weight; Stockmayer-Fixman; unperturbed dimensions; viscosity; 14054.  
<sup>1</sup>ΔO<sub>2</sub>; lasers; photochemistry; 14635.  
 1st negative band; crossed beams; cross sections; excitation of N<sub>2</sub><sup>+</sup>; 14446.  
 10-MeV electrons; aluminum; carbon; depth dose; depth-dose distributions; dye-film dosimeters; polyethylene; polystyrene; radiochromic dyes; NBSIR 73-413.  
 10.6 μm; etch-polishing; KCl; laser damage; laser windows; RAP; SP414, pp. 66-75.  
 1.06 μm; oxygen deficiency; surface damage; surface treatment; LiNbO<sub>3</sub>; SP414, pp. 131-134.  
 1,1-difluoroethane; 1,1,1-trifluoroethane; elimination;



- fluoroethane; kinetics; single pulse shock tube; thermal decomposition; *14199*.
- 1,1,1-trifluoroethane; elimination; fluoroethane; kinetics; single pulse shock tube; thermal decomposition; 1,1-difluoroethane; *14199*.
- 1,1,2,2-tetramethylcyclopropane; cyclohexene; decomposition; decyclization; shock tube; 2,4-dimethylpentene-2; *14196*.
- 1,2,4-trichlorobenzene; fractionation; limiting viscosity number; linear polyethylene; Mark-Houwink; molecular weight; Stockmayer-Fixman; unperturbed dimensions; viscosity; 1-chloronaphthalene; *14054*.
- <sup>13</sup>C-H coupling constants; fluorinated chemical shift reagents; Fourier transform <sup>13</sup>C magnetic resonance spectroscopy; glycosyl cyanides; *14147*.
- <sup>137</sup>Cs; standards; cavity ionization chamber; exposure; gamma rays; <sup>60</sup>Co; *J.78A No. 4, 465-476 (1974)*.
- <sup>19</sup>F; <sup>35</sup>Cl; angular-momentum; correlation-times; molecular-reorientation; NMR-relaxation-times; *14422*.
- 2-methylbutane; pentane; ultrasonics; bulk modulus; compressibility; density; dilatometric measurements; high pressure; liquids; *J.78A No. 5, 617-622 (1974)*.
- <sup>235</sup>U; <sup>238</sup>U; MeV neutrons; time-of-flight; total neutron cross sections; <sup>239</sup>Pu; *14435*.
- <sup>238</sup>U; MeV neutrons; time-of-flight; total neutron cross sections; <sup>239</sup>Pu; <sup>235</sup>U; *14435*.
- <sup>239</sup>Pu; <sup>235</sup>U; <sup>238</sup>U; MeV neutrons; time-of-flight; total neutron cross sections; *14435*.
- 2,4-dimethylhexene-1; bond strength; combination rate; decomposition; isobutenyl; shock tube; *14044*.
- 2,4-dimethylpentene-2; 1,1,2,2-tetramethylcyclopropane; cyclohexene; decomposition; decyclization; shock tube; *14196*.
- 2-ports; waveguide; waveguide discontinuities; automatic network analyzers; coaxial; coaxial line step discontinuities; group delay; scattering coefficients; standards; *TN657*.
- <sup>252</sup>Cf; age; fission spectrum; neutron; neutron age; *14470*.
- 30 and 57.4 MeV electrons; angular distribution; depth-dose; photon energy; Ta target; thermoluminescent detectors; *14040*.
- <sup>35</sup>Cl; angular-momentum; correlation-times; molecular-reorientation; NMR-relaxation-times; <sup>19</sup>F; *14422*.
- 360° scattering by particles; aerosol light scattering; aerosol size measurements; aerosol spectrometer; aerosol sprays; laser light scattering by aerosols; refractive index; scattering diagrams; *SP412*, pp. 41-56.
- <sup>4</sup>He; condensate fraction; ground state wave function; neutron diffraction; pair correlation function; triplet correlation function; *13943*.
- 4π β-γ coincidence counting; γ-ray intercomparator automatic sample changers; radioactivity measurements; *14301*.
- 4,4',4''-triaminotriphenylacetone; triphenyl-methane dyes; dosimetry; dyes; dye yield; gamma rays; pararosanine cyanide; *14292*.
- <sup>60</sup>Co gamma-ray irradiation; LiF (LTD grade) plaques; readout; thermoluminescence; annealing; *f* centers; *14322*.
- <sup>60</sup>Co; <sup>137</sup>Cs; standards; cavity ionization chamber; exposure; gamma rays; *J.78A No. 4, 465-476 (1974)*.
- 77 K refrigerator; cryogenics; infrared detector; low capacity; reliability; shipboard; *14305*.



# APPENDIX A. LIST OF DEPOSITORY LIBRARIES IN THE UNITED STATES

## ALABAMA

Alexander City: Alexander City State Junior College, Thomas D. Russell Library (1967).  
Auburn: Auburn University, Ralph Brown Draughon Library (1907).  
Birmingham:  
    Birmingham Public Library (1895).  
    Birmingham-Southern College Library (1932).  
    Jefferson State Junior College, James B. Allen Library (1970).  
    Samford University, Harwell G. Davis Library (1884).  
Enterprise: Enterprise State Junior College Library (1967).  
Florence: Florence State University, Collier Library (1932).  
Gadsden: Gadsden Public Library (1963).  
Huntsville: University of Alabama, Huntsville Campus Library (1964).  
Jacksonville: Jacksonville State University, Ramona Wood Library (1929).  
Maxwell A.F. Base: Air University Library (1963).  
Mobile:  
    Mobile Public Library (1963).  
    Spring Hill College, Thomas Byrne Memorial Library (1937).  
    University of South Alabama Library (1968).  
Montgomery:  
    Alabama State Department of Archives and History Library (1884).  
    Alabama Supreme Court Library (1884).  
    Auburn University at Montgomery Library (1971).  
Normal: Alabama Agricultural and Mechanical College, Drake Memorial Library (1963).  
St. Bernard: St. Bernard College Library (1962).  
Troy: Troy State University, Lurleen B. Wallace Educational Resources Center (1963).  
Tuskegee Institute: Tuskegee Institute, Hollis Burke Frissell Library (1907).  
University:  
    University of Alabama, School of Law Library (1967).  
    University of Alabama Library (1860) – REGIONAL

## ALASKA

Anchorage:  
    Anchorage Higher Consortium Library (1961).  
    Alaska Methodist University Library (1963).  
    Supreme Court of Alaska Library (1973).  
College: University of Alaska, Elmer E. Rasmuson Library (1922).  
Juneau: Alaska State Library (1964).  
Ketchikan: Ketchikan Community College Library (1970).

## ARIZONA

Coolidge: Central Arizona College, Instructional Materials Center (1973).  
Flagstaff: Northern Arizona University Library (1937).  
Phoenix:  
    Department of Library and Archives (unknown) – REGIONAL.

Phoenix Public Library (1917).  
Prescott: Prescott College Library (1968).  
Tempe: Arizona State University, A. J. Matthews Library (1944).  
Thatcher: Eastern Arizona Junior College Library (1963).  
Tucson:  
    Tucson Public Library (1970).  
    University of Arizona Library (1907) – REGIONAL.  
Yuma: Yuma City-County Library (1963).

## ARKANSAS

Arkadelphia: Quachita Baptist University, Riley Library (1963).  
Batesville: Arkansas College Library (1963).  
Clarksville: College of the Ozarks Library (1925).  
Conway: Hendrix College, O. C. Bailey Library (1903).  
Fayetteville: University of Arkansas Library (1907).  
Little Rock:  
    Arkansas Supreme Court Library (1962).  
    Little Rock Public Library (1953).  
    University of Arkansas at Little Rock Library (1973).  
Magnolia: Southern State College, J. M. Peace Library (1956).  
Monticello: University of Arkansas at Monticello Library (1956).  
Pine Bluff: Arkansas Agricultural, Mechanical and Normal College Library (pending).  
Russellville: Arkansas Polytechnic College, Tomlinson Library (1925).  
Searcy: Harding College, Beaumont Memorial Library (1963).  
State College: Arkansas State University, Dean B. Ellis Library (1913).  
Walnut Ridge: Southern Baptist College, Felix Goodson Library (1967).

## CALIFORNIA

Anaheim: Anaheim Public Library (1963).  
Arcata: Humboldt State College Library (1963).  
Bakersfield:  
    California State College, Bakersfield Library (1974).  
    Kern County Library System (1943).  
Berkeley:  
    University of California, General Library (1907).  
    University of California, Law Library, Earl Warren Legal Center (1963).  
Carson: Carson Regional Library (1973).  
Chico: Chico State University Library (1962).  
Claremont: Pomona College Documents Collection, Honnold Library (1913).  
Compton: Compton Library (1972).  
Culver City: Culver City Library (1966).  
Davis:  
    University of California at Davis Library (1953).  
    University of California at Davis, School of Law Library (1972).  
Dominguez Hills: California State College, Dominguez Hills, Educational Resources Center (1973).  
Downey: Downey City Library (1963).  
Fresno:  
    Fresno County Free Library (1920).  
    Fresno State University Library (1962).



Fullerton: California State College at Fullerton Library (1963).  
 Garden Grove: Garden Grove Regional Library (1963).  
 Gardena: Gardena Public Library (1966).  
 Hayward: California State College at Hayward Library (1963).  
 Huntington Park: Huntington Park Library, San Antonio Region (1970).  
 Inglewood: Inglewood Public Library (1963).  
 Irvine: University of California at Irvine Library (1963).  
 La Jolla: University of California, San Diego, University Library (1963).  
 Lakewood: Angelo Iacoboni Public Library (1970).  
 Lancaster: Lancaster Regional Library (1967).  
 Long Beach:  
   California State College at Long Beach Library (1962).  
   Long Beach Public Library (1933).  
 Los Angeles:  
   California State College at Los Angeles, John F. Kennedy Memorial Library (1956).  
   Los Angeles County Law Library (1963).  
   Los Angeles Public Library (1891).  
   Loyola University of Los Angeles Library (1933).  
   Occidental College, Mary Norton Clapp Library (1941).  
   Pepperdine University Library (1963).  
   University of California at Los Angeles Library (1932).  
   University of California at Los Angeles, Law Library (1958).  
   University of Southern California Library (1933).  
 Menlo Park: U.S. Geological Survey Library (1962).  
 Montebello: Montebello Library (1966).  
 Monterey: U.S. Naval Postgraduate School Library (1963).  
 Monterey Park: Bruggemeyer Memorial Library (1964).  
 Northridge: California State University at Northridge Library (1958).  
 Norwalk: Los Cerritos Regional Library (1973).  
 Oakland:  
   Mills College Library (1966).  
   Oakland Public Library (1923).  
 Ontario: Ontario City Library (1974).  
 Pasadena:  
   California Institute of Technology, Millikan Memorial Library (1933).  
   Pasadena Public Library (1963).  
 Pleasant Hill: Contra Costa County Library (1964).  
 Redding: Shasta County Library (1956).  
 Redlands: University of Redlands, Armacost Library (1933).  
 Redwood City: Redwood City Public Library (1966).  
 Reseda: West Valley Regional Branch Library (1966).  
 Richmond: Richmond Public Library (1943).  
 Riverside:  
   Riverside Public Library (1947).  
   University of California at Riverside Library (1963).  
 Sacramento:  
   California State Library (1895)—REGIONAL.  
   Sacramento City-County Library (1880).  
   Sacramento County Law Library (1963).  
   Sacramento State College Library (1963).  
 San Bernardino: San Bernardino County Free Library (1964).  
 San Diego:  
   San Diego County Library (1966).  
   San Diego Public Library (1895).  
   San Diego State University, Love Library (1962).  
   San Diego County Law Library (1973).  
 San Francisco:  
   Mechanics' Institute Library (1889).  
   San Francisco Public Library (1889).  
   San Francisco State College, Social Science and Business Library (1955).  
   Supreme Court of California Library (1972).  
   U.S. Court of Appeals for Ninth Circuit Library (1971).

University of San Francisco, Richard A. Gleeson Library (1963).  
 San Jose: San Jose State College Library (1962).  
 San Leandro: San Leandro Community Library Center (1961).  
 San Luis Obispo: California State Polytechnic University Library (1969).  
 Santa Ana: Santa Ana Public Library (1959).  
 Santa Barbara: University of California at Santa Barbara Library (1960).  
 Santa Clara: University of Santa Clara, Orradre Library (1963).  
 Santa Cruz: University of California at Santa Cruz Library (1963).  
 Santa Rosa: Santa Rosa-Sonoma County Public Library (1896).  
 Stanford: Stanford University Libraries (1895).  
 Stockton: Public Library of Stockton and San Joaquin County (1884).  
 Thousand Oaks: California Lutheran College Library (1964).  
 Torrance: Torrance Civic Center Library (1969).  
 Turlock: Stanislaus State College Library (1964).  
 Valencia: Valencia Regional Library (1972).  
 Van Nuys: Los Angeles Valley College Library (1970).  
 Visalia: Tulare County Free Library (1967).  
 Walnut: Mount San Antonio College Library (1966).  
 West Covina: West Covina Library (1966).  
 Whittier: Whittier College, Wardman Library (1963).

## CANAL ZONE

Balboa Heights: Canal Zone Library-Museum (1963).

## COLORADO

Alamosa: Adams State College Learning Resources Center (1963).  
 Boulder: University of Colorado Libraries (1879)—REGIONAL.  
 Colorado Springs: Colorado College, Charles Leaming Tutt Library (1880).  
 Denver:  
   Colorado State Library (unknown).  
   Denver Public Library (1884)—REGIONAL.  
   Regis College, Dayton Memorial Library (1915).  
   University of Denver, Penrose Library (1909).  
   U.S. Bureau of Reclamation Library (1962).  
   U.S. Court of Appeals for Tenth Circuit Library (1973).  
 Fort Collins: Colorado State University Library (1907).  
 Golden:  
   Colorado School of Mines, Arthur Lakes Library (1939).  
   Jefferson County Public Library, Bonfils-Stanton Regional Library (1968).  
 Greeley: University of Northern Colorado Library (1966).  
 Gunnison: Western State College, Leslie J. Savage Library (1932).  
 La Junta: Otero Junior College, Wheeler Library (1963).  
 Pueblo:  
   Pueblo Regional Library (1893).  
   Southern Colorado State College Library (1965).  
 U.S. Air Force Academy: Academy Library (1956).

## CONNECTICUT

Bridgeport: Bridgeport Public Library (1884).  
 Danbury: Western Connecticut State College Library (1967).  
 Enfield: Enfield Public Library (1967).  
 Hartford:  
   Connecticut State Library (unknown)—REGIONAL.



Hartford Public Library (1945).  
 Trinity College Library (1895).  
 Middletown: Wesleyan University, Olin Library (1906).  
 Mystic: Marine Historical Association, Inc., Mystic Seaport Library (1964).  
 New Britain: Central Connecticut State College, Elihu Burritt Library (1973).  
 New Haven:  
   Southern Connecticut State College Library (1968).  
   Yale University, Sterling Memorial Library (1859).  
 New London:  
   Connecticut College Library (1926).  
   U.S. Coast Guard Academy Library (1939).  
 Pomfret: Pomfret School, du Pont Library (1968).  
 Stamford: Stamford Public Library (1973).  
 Storrs: University of Connecticut, Wilbur Cross Library (1907).  
 Waterbury: Silas Bronson Library (1869).  
 West Haven: University of New Haven Library (1971).

## DELAWARE

Dover:  
   Delaware State College, William C. Jason Library (1962).  
   State Department of Community Affairs and Economic Development, Division of Libraries (1972).  
   State Law Library in Kent County (unknown).  
 Georgetown: Delaware Technical and Community College, Southern Branch Library (1968).  
 Newark: University of Delaware, Morris Library (1907).  
 Wilmington:  
   New Castle County Law Library (1974).  
   Wilmington Institute and New Castle County Library (1861).

## DISTRICT OF COLUMBIA

Washington:  
   Advisory Commission on Intergovernmental Relations Library.  
   Department of Agriculture, National Agricultural Library (1895).  
   Department of Commerce Library (1955).  
   Department of Health, Education, and Welfare Library (1895).  
   Department of Housing and Urban Development Library (1969).  
   Department of the Interior Central Library (1895).  
   Department of Justice Main Library (1895).  
   Department of State Library (1895).  
   Department of State, Office of Legal Advisor, Law Library (1966).  
   Department of Transportation, National Highway Traffic Safety Administration Library (1968).  
   District of Columbia Public Library (1943).  
   District of Columbia Court of Appeals Library (1973).  
   Federal City College Library (1970).  
   Federal Deposit Insurance Corporation Library (1972).  
   Georgetown University Library (1969).  
   Indian Claims Commission Library (1968).  
   National War College Library (1895).  
   Navy Department Library (1895).  
   Office of the Judge Advocate General Library, Department of Navy (1963).  
   Office of Management and Budget Library, Executive Office of the President (1965).  
   Office of the Adjutant General, Department of Army Library (1969).

Treasury Department Library (1895).  
 U.S. Postal Service Library (1895).  
 U.S. Civil Service Commission Library (1963).  
 U.S. Geological Survey Library (1962).  
 Veterans Administration, Central Office Library (1967).

## FLORIDA

Boca Raton: Florida Atlantic University Library (1963).  
 Clearwater: Clearwater Public Library (1972).  
 Coral Gables: University of Miami Library (1939).  
 Daytona Beach: Volusia County Public Libraries (1963).  
 DeLand: Stetson University, duPont-Ball Library (1887).  
 Fort Lauderdale:  
   Fort Lauderdale Public Library (1967).  
   Nova University Library (1967).  
 Gainesville: University of Florida Libraries (1907)—REGIONAL.  
 Jacksonville:  
   Haydon Burns Library (1914).  
   Jacksonville University, Swisher Library (1962).  
   University of North Florida Library (1972).  
 Lakeland: Lakeland Public Library (1928).  
 Leesburg: Lake-Sumter Community College Library (1963).  
 Melbourne: Florida Institute of Technology Library (1963).  
 Miami:  
   Florida International University Library (1970).  
   Miami Public Library (1952).  
 Opa Locka: Biscayne College Library (1966).  
 Orlando: Florida Technological University Library (1966).  
 Palatka: St. Johns River Junior College Library (1963).  
 Pensacola: University of West Florida, John C. Pace Library (1966).  
 Port Charlotte: Charlotte County Library System (1973).  
 St. Petersburg: St. Petersburg Public Library (1965).  
 Sarasota: Sarasota Public Library (1970).  
 Tallahassee:  
   Florida Agricultural and Mechanical University, Coleman Memorial Library (1936).  
   Florida State Library (1929).  
   Florida State University, R. M. Strozier Library (1941).  
 Tampa:  
   Tampa Public Library (1965).  
   University of South Florida Library (1962).  
   University of Tampa, Merle Kelce Library (1953).  
 Winter Park: Rollins College, Mills Memorial Library (1909).

## GEORGIA

Albany: Albany Public Library (1964).  
 Americus: Georgia Southwestern College, James Earl Carter Library (1966).  
 Athens: University of Georgia Libraries (1907).  
 Atlanta:  
   Atlanta Public Library (1880).  
   Atlanta University, Trevor Arnett Library (1962).  
   Emory University, Robert W. Woodruff Library (1928).  
   Emory University, School of Law Library (1968).  
   Georgia Institute of Technology, Price Gilbert Memorial Library (1963).  
   Georgia State Library (unknown).  
   Georgia State University Library (1970).  
 Augusta: Augusta College Library (1962).  
 Brunswick: Brunswick Public Library (1965).  
 Carrollton: West Georgia College, Sanford Library (1962).  
 Dahlonega: North Georgia College Library (1939).  
 Decatur: Dekalb Community College-South Campus, Learning Resources Center (1973).



Gainesville: Chestatee Regional Library (1968).  
 Macon: Mercer University, Stetson Memorial Library (1964).  
 Marietta: Kennesaw Junior College Library (1968).  
 Milledgeville: Georgia College at Milledgeville, Ina Dillard Russell Library (1950).  
 Mount Berry: Berry College, Memorial Library (1970).  
 Savannah: Savannah Public and Chatham-Effingham Liberty Regional Library (1857).  
 Statesboro: Georgia Southern College, Rosenwald Library (1939).  
 Valdosta: Valdosta State College, Richard Holmes Powell Library (1956).

## GUAM

Agana: Nieves M. Flores Memorial Library (1962).

## HAWAII

Hilo: University of Hawaii, Hilo Campus Library (1962).  
 Honolulu:  
     Chaminade College of Honolulu Library (1965).  
     Hawaii Medical Library, Inc. (1968).  
     Hawaii State Library (1929).  
     Municipal Reference Library of the City and County of Honolulu (1965).  
     Supreme Court Law Library (1973).  
     University of Hawaii Library (1907).  
 Laie: Church College of Hawaii, Woolley Library (1964).  
 Lihue: Kauai Public Library (1967).  
 Pearl City: Leeward Community College Library (1967).  
 Wailuku: Maui Public Library (1962).

## IDAHO

Boise:  
     Boise State College Library (1966).  
     Boise Public Library and Information Center (1929).  
     Idaho State Law Library (unknown).  
     Idaho State Library (1971).  
 Caldwell: College of Idaho, Terteling Library (1930).  
 Moscow: University of Idaho Library (1907) – REGIONAL.  
 Pocatello: Idaho State University Library (1908).  
 Rexburg: Ricks College, David O. McKay Library (1946).  
 Twin Falls: College of Southern Idaho Library (1970).

## ILLINOIS

Bloomington: Illinois Wesleyan University Libraries (1964).  
 Carbondale: Southern Illinois University, Morris Library (1932).  
 Carlinville: Blackburn College Library (1954).  
 Carterville: Shawnee Library System (1971).  
 Champaign: University of Illinois Law Library, College of Law (1965).  
 Charleston: Eastern Illinois University, Booth Library (1962).  
 Chicago:  
     Field Museum of Natural History Library (1963).  
     Chicago Public Library (1876).  
     Chicago State University Library (1954).  
     John Crerar Library (1909).  
     Loyola University of Chicago, E. M. Cudahy Memorial Library (1966).  
     Newberry Library (1890).  
     Northeastern Illinois University Library (1961).  
     University of Chicago Law Library (1964).

University of Chicago Library (1897).  
 University of Illinois, Chicago Circle Campus Library (1957).  
 Decatur: Decatur Public Library (1954).  
 De Kalb: Northern Illinois University, Swen Franklin Parson Library (1960).  
 Edwardsville: Southern Illinois University, Lovejoy Library (1959).  
 Elmhurst: Principia College, Marshall Brooks Library (1957).  
 Evanston: Northwestern University Library (1876).  
 Freeport: Freeport Public Library (1905).  
 Galesburg: Galesburg Public Library (1896).  
 Jacksonville: MacMurray College, Henry Pfeiffer Library (1929).  
 Kankakee: Olivet Nazarene College, Memorial Library (1946).  
 Lake Forest: Lake Forest College, Donnelley Library (1962).  
 Lebanon: McKendree College, Holman Library (1968).  
 Lisle: Illinois Benedictine College, Theodore F. Lownik Library (1911).  
 Lockport: Lewis College of Science and Technology Library (1952).  
 Macomb: Western Illinois University Memorial Library (1962).  
 Moline: Black Hawk College, Learning Resources Center (1970).  
 Monmouth: Monmouth College Library (1860).  
 Normal: Illinois State University, Milner Library (1877).  
 Oak Park: Oak Park Public Library (1963).  
 Palos Hills: Moraine Valley Community College Library (1972).  
 Peoria:  
     Bradley University, Cullom Davis Library (1963).  
     Peoria Public Library (1883).  
 River Forest: Rosary College Library (1966).  
 Rockford: Rockford Public Library (unknown).  
 Springfield: Illinois State Library (unknown) – REGIONAL.  
 Urbana: University of Illinois Library (1907).  
 Wheaton: Wheaton College Library (1964).  
 Woodstock: Woodstock Public Library (1963).

## INDIANA

Anderson: Anderson College, Charles E. Wilson Library (1959).  
 Bloomington: Indiana University Library (1881).  
 Crawfordsville: Wabash College, Lilly Library (1906).  
 Evansville:  
     Evansville and Vanderburgh County Public Library (1928).  
     Indiana State University, Evansville Campus Library (1969).  
 Fort Wayne:  
     Indiana-Purdue University Regional Campus Library (1965).  
     Public Library of Fort Wayne and Allen County (1896).  
 Franklin: Franklin College Library (pending).  
 Gary:  
     Gary Public Library (1943).  
     Indiana University, Northwest Campus Library (1966).  
 Greencastle: De Pauw University, Roy O. West Library (1879).  
 Hammond: Hammond Public Library (1964).  
 Hanover: Hanover College Library (1892).  
 Huntington: Huntington College Library (1964).  
 Indianapolis:  
     Butler University, Irwin Library (1965).  
     Indiana State Library (unknown) – REGIONAL.  
     Indiana University, Law Library (1967).  
     Indianapolis-Marion County Public Library (1967).  
 Jeffersonville: Indiana University, Southeastern Campus Library (1965).  
 Kokomo: Indiana University, Kokomo Regional Campus Library (1969).  
 Lafayette: Purdue University Library (1907).



**Muncie:**  
 Ball State University Library (1959).  
 Muncie Public Library (1906).  
**Notre Dame:** University of Notre Dame, Memorial Library (1883).  
**Rensselaer:** St. Joseph's College Library (1964).  
**Richmond:**  
 Earlham College, Lilly Library (1964).  
 Morrison-Reeves Library (1906).  
**South Bend:** Indiana University at South Bend Library (1965).  
**Terre Haute:** Indiana State University, Cunningham Memorial Library (1906).  
**Valparaiso:** Valparaiso University, Moellering Memorial Library (1930).

## IOWA

**Ames:** Iowa State University of Science and Technology Library (1907).  
**Cedar Falls:** University of Northern Iowa Library (1946).  
**Council Bluffs:**  
 Free Public Library (1885).  
 Iowa Western Community College, Hoover Media Library (1972).  
**Davenport:** Davenport Public Library (1973).  
**Des Moines:**  
 Drake University, Cowles Library (1966).  
 Drake University Law Library (1972).  
 Iowa State Traveling Library (unknown).  
 Public Library of Des Moines (1888).  
**Dubuque:**  
 Carnegie-Stout Public Library (unknown).  
 Loras College, Wahlert Memorial Library (1967).  
**Grinnell:** Grinnell College, Burling Library (1874).  
**Iowa City:**  
 University of Iowa, Law Library (1968).  
 University of Iowa Library (1884)—REGIONAL.  
**Lamoni:** Graceland College, Frederick Madison Smith Library (1927).  
**Mount Vernon:** Cornell College, Russell D. Cole Library (1896).  
**Orange City:** Northwestern College, Ramaker Library (1970).  
**Sioux City:** Sioux City Public Library (1894).

## KANSAS

**Atchison:** Benedictine College Library (1965).  
**Baldwin City:** Baker University Library (1908).  
**Colby:** Colby Community Junior College Library (1968).  
**Emporia:** Kansas State Teachers College, William Allen White Library (1909).  
**Hays:** Fort Hays Kansas State College, Forsyth Library (1926).  
**Hutchinson:** Hutchinson Public Library (1963).  
**Lawrence:**  
 University of Kansas, Watson Library (1869).  
 University of Kansas Law Library (1971).  
**Manhattan:** Kansas State University, Farrell Library (1907).  
**Pittsburg:** Kansas State College of Pittsburg, Porter Library (1952).  
**Salina:** Kansas Wesleyan University, Memorial Library (1930).  
**Topeka:**  
 Kansas State Historical Society Library (1877).  
 Kansas State Library (unknown).  
 Washburn University of Topeka, Law Library (1971).  
**Wichita:** Wichita State University Library (1901).

## KENTUCKY

**Ashland:** Ashland Public Library (1946).

**Barbourville:** Union College, Abigail E. Weeks Memorial Library (1958).  
**Bowling Green:** Western Kentucky University, Cravens Graduate Center and Library (1934).  
**Covington:** Thomas More College Library (1970).  
**Danville:** Centre College, Grace Doherty Library (1884).  
**Frankfort:**  
 Kentucky Department of Libraries (1967).  
 Kentucky State University, Blazer Library (1972).  
 State Law Library (unknown).  
**Highland Heights:** Northern Kentucky State College Library (1973).  
**Lexington:**  
 University of Kentucky, Law Library (1968).  
 University of Kentucky, Margaret I. King Library (1907)—REGIONAL.  
**Louisville:**  
 Louisville Free Public Library (1904).  
 University of Louisville, Belknap Campus Library (1925).  
**Morehead:** Morehead State University, Johnson Camden Library (1955).  
**Murray:** Murray State University Library (1924).  
**Owensboro:** Kentucky Wesleyan College Library (1966).  
**Pikeville:** Pikeville College Library (1947).  
**Richmond:** Eastern Kentucky University, John Grant Crabbe Library (1966).

## LOUISIANA

**Baton Rouge:**  
 Louisiana State University Law Library (1929).  
 Louisiana State University Library (1907)—REGIONAL.  
 Southern University Library (1952).  
**Eunice:** Louisiana State University at Eunice, LeDoux Library (1969).  
**Hammond:** Southeastern Louisiana University, Sims Memorial Library (1966).  
**Lafayette:** University of Southwestern Louisiana Library (1938).  
**Lake Charles:** McNeese State University, Frazar Memorial Library (1941).  
**Monroe:** Northeast Louisiana University, Sandel Library (1963).  
**Natchitoches:** Northwestern State University, Watson Memorial Library (1887).  
**New Orleans:**  
 Isaac Delgado College, Moss Technical Library (1968).  
 Law Library of Louisiana (unknown).  
 Loyola University Library (1942).  
 New Orleans Public Library (1883).  
 Southern University in New Orleans Library (1962).  
 Tulane University, Howard-Tilton Memorial Library (1942).  
 University of New Orleans Library (1963).  
 U.S. Court of Appeals for Fifth Circuit Library (1973).  
**Pineville:** Louisiana College, Richard W. Norton Memorial Library (1969).  
**Ruston:** Louisiana Technical University Library (1896)—REGIONAL.  
**Shreveport:**  
 Louisiana State University at Shreveport Library (1967).  
 Shreve Memorial Library (1923).  
**Thibodaux:** Francis T. Nicholls State University, Leonidas Polk Library (1962).

## MAINE

**Augusta:**  
 Maine Law and Legislative Reference Library (1973).



Maine State Library (unknown).  
 Bangor: Bangor Public Library (1884).  
 Brunswick: Bowdoin College, Hawthorne-Longfellow Library (1884).  
 Castine: Maine Maritime Academy, Nutting Memorial Library (1969).  
 Lewiston: Bates College Library (1883).  
 Orono: University of Maine, Raymond H. Fogler Library (1907)–REGIONAL.  
 Portland:  
   Portland Public Library (1884).  
   University of Maine Law Library (1964).  
 Springvale: Nason College Library (1961).  
 Waterville: Colby College Library (1884).

## MARYLAND

Annapolis:  
   Maryland State Library (unknown).  
   U.S. Naval Academy, Nimitz Library (1895).  
 Baltimore:  
   Enoch Pratt Free Library (1887).  
   Johns Hopkins University, Milton S. Eisenhower Library (1882).  
   Morgan State College, Soper Library (1940).  
   University of Baltimore, Langsdale Library (1973).  
   University of Maryland, Baltimore County Library (1971).  
   University of Maryland, School of Law Library (1969).  
 Bel Air: Harford Community College Library (1967).  
 Chestertown: Washington College, Chester M. Miller Library (1891).  
 College Park: University of Maryland, McKeldin Library (1925)–REGIONAL  
 Frostburg: Frostburg State College Library (1967).  
 Germantown: U.S. Atomic Energy Commission Headquarters Library (1963).  
 Patuxent River: U.S. Naval Air Station Library (1968).  
 Rockville: Montgomery County Department of Public Libraries (1951).  
 Salisbury: Salisbury State College, Blackwell Library (1965).  
 Towson: Goucher College, Julia Rogers Library (1966).  
 Westminster: Western Maryland College Library (1896).

## MASSACHUSETTS

Amherst:  
   Amherst College Library (1884).  
   University of Massachusetts, Goodell Library (1907).  
 Belmont: Belmont Memorial Library (1968).  
 Boston:  
   Boston Athenaeum Library (unknown).  
   Boston Public Library (1859)–REGIONAL.  
   Northeastern University, Robert G. Dodge Library (1962).  
   State Library of Massachusetts (unknown).  
 Brookline: Public Library of Brookline (1925).  
 Cambridge:  
   Harvard College Library (1860).  
   Massachusetts Institute of Technology Libraries (1946).  
 Chestnut Hill: Boston College, Bapst Library (1963).  
 Chicopee: Our Lady of the Elms College Library (1969).  
 Lowell: Lowell Technological Institute, Alumni Memorial Library (1952).  
 Lynn: Lynn Public Library (1953).  
 Marlborough: Marlborough Public Library (1971).  
 Medford: Tufts University Library (1899).  
 Milton: Curry College Library (1972).  
 New Bedford: New Bedford Free Public Library (1858).  
 North Dartmouth: Southeastern Massachusetts University Library (1965).

North Easton: Stonehill College, Cushing-Martin Library (1962).  
 Springfield: Springfield City Library (1966).  
 Waltham: Brandeis University, Goldfarb Library (1965).  
 Wellesley: Wellesley College Library (1943).  
 Wenham: Gordon College, Winn Library (1963).  
 Williamstown: Williams College Library (unknown).  
 Wilmington: Wilmington Memorial Library (1971).  
 Worcester:  
   American Antiquarian Society Library (1814).  
   University of Massachusetts, Medical Center Library (1972).  
   Worcester Public Library (1859).

## MICHIGAN

Albion: Albion College, Stockwell Memorial Library (1966).  
 Allendale: Grand Valley State College Library (1963).  
 Alma: Alma College, Monteith Library (1963).  
 Ann Arbor:  
   Great Lakes Basin Library (1971).  
   University of Michigan, Harlan Hatcher Library (1884).  
 Benton Harbor: Benton Harbor Public Library (1907).  
 Bloomfield Hills: Cranbrook Institute of Science Library (1940).  
 Dearborn:  
   Henry Ford Centennial Library (1969).  
   Henry Ford Community College Library (1957).  
 Detroit:  
   Detroit Public Library (1868)–REGIONAL.  
   Marygrove College Library (1965).  
   Mercy College of Detroit Library (1965).  
   University of Detroit Library (1884).  
   Wayne County Public Library (1957).  
   Wayne State University Law Library (1971).  
   Wayne State University, G. Flint Purdy Library (1937).  
 Dowagiac: Southwestern Michigan College Library (1971).  
 East Lansing:  
   Michigan State University, Law Library (1971).  
   Michigan State University Library (1907).  
 Escanaba: Michigan State Library, Upper Peninsula Branch (1964).  
 Farmington: Martin Luther King Learning Resources Center, Oakland Community College (1968).  
 Flint:  
   Charles Stewart Mott Library (1959).  
   Flint Public Library (1967).  
 Grand Rapids:  
   Grand Rapids Public Library (1876).  
   Calvin College Library (1967).  
 Houghton: Michigan Technological University Library (1876).  
 Jackson: Jackson Public Library (1965).  
 Kalamazoo:  
   Kalamazoo Library System (1907).  
   Western Michigan University, Dwight B. Waldo Library (1963).  
 Lansing: Michigan State Library (unknown)–REGIONAL.  
 Livonia: Schoolcraft College Library (1962).  
 Marquette: Northern Michigan University, Olson Library (1963).  
 Monroe: Monroe County Library System (pending).  
 Mt. Clemens: Macomb County Library (1968).  
 Mt. Pleasant: Central Michigan University Library (1958).  
 Muskegon: Hackley Public Library (1894).  
 Petoskey: North Central Michigan College Library (1962).  
 Port Huron: Saint Clair County Library System (1876).  
 Rochester: Oakland University, Kresge Library (1964).  
 Saginaw: Hoyt Public Library (1890).  
 Traverse City: Northwestern Michigan College, Mark Osterlin Library (1964).



University Center: Delta College Library (1963).  
Warren: Warren Public Library, Arthur J. Miller Branch (1973).  
Ypsilanti: Eastern Michigan University Library (1965).

## MINNESOTA

Bemidji: Bemidji State College, A. C. Clark Library (1963).  
Collegeville: St. John's University, Alcuin Library (1954).  
Duluth: Duluth Public Library (1909).  
Mankato: Mankato State College Memorial Library (1962).  
Minneapolis:  
    Anoka County Library (1971).  
    Southdale-Hennepin Area Library (1971).  
    Minneapolis Public Library (1893).  
    University of Minnesota, Wilson Library (1907)—REGIONAL.  
Moorhead: Moorhead State College Library (1956).  
Morris: University of Minnesota at Morris Library (1963).  
Northfield:  
    Carleton College Library (1930).  
    St. Olaf College, Rolvaag Memorial Library (1930).  
St. Cloud: St. Cloud State College Library (1962).  
St. Paul:  
    Minnesota Historical Society Library (1867).  
    Minnesota State Law Library (unknown).  
    St. Paul Public Library (1914).  
    University of Minnesota, St. Paul Campus Library (1974).  
Saint Peter: Gustavus Adolphus College Library (1941).  
Stillwater: Stillwater Public Library (1893).  
Willmar: Crow River Regional Library (1958).  
Winona: Winona State College, Maxwell Library (1969).

## MISSISSIPPI

Columbus: Mississippi State College for Women, J. C. Fant Memorial Library (1929).  
Hattiesburg: University of Southern Mississippi Library (1935).  
Jackson:  
    Jackson State College Library (1968).  
    Millsaps College, Millsaps-Wilson Library (1963).  
    Mississippi Library Commission (1947).  
    Mississippi State Law Library (unknown).  
Lorman: Alcorn Agricultural and Mechanical College Library (1970).  
State College: Mississippi State University, Mitchell Memorial Library (1907).  
University:  
    University of Mississippi Library (1883).  
    University of Mississippi, School of Law Library (1967).

## MISSOURI

Cape Girardeau: Southeast Missouri State College, Kent Library (1916).  
Columbia: University of Missouri Library (1862).  
Fayette: Central Methodist College Library (1962).  
Fulton: Westminster College, Reeves Library (1875).  
Jefferson City:  
    Lincoln University, Inman E. Page Library (1944).  
    Missouri State Library (1963).  
    Missouri Supreme Court Library (unknown).  
Joplin: Missouri Southern State College Library (1966).  
Kansas City:  
    Kansas City Public Library (1881).  
    Rockhurst College Library (1917).  
    University of Missouri at Kansas City, General Library (1938).

Kirkville: Northeast Missouri State Teachers College, Pickler Memorial Library (1966).  
Liberty: William Jewell College Library (1900).  
Rolla: University of Missouri at Rolla Library (1907).  
St. Charles: Lindenwood College, Margaret Leggat Butler Library (1973).  
St. Joseph: St. Joseph Public Library (1891).  
St. Louis:  
    St. Louis County Library (1970).  
    St. Louis Public Library (1866).  
    St. Louis University, Law Library (1967).  
    St. Louis University, Pius XII Memorial Library (1866).  
    University of Missouri at St. Louis, Thomas Jefferson Library (1966).  
    U.S. Court of Appeals, Eighth Circuit Library (1972).  
    Washington University, John M. Olin Library (1906).  
Springfield:  
    Drury College, Walker Library (1874).  
    Southwest Missouri State College Library (1963).  
Warrensburg: Central Missouri State College, Ward Edwards Library (1914).

## MONTANA

Billings: Eastern Montana College Library (1924).  
Bozeman: Montana State University Library (1907).  
Butte: Montana College of Mineral Science and Technology Library (1901).  
Helena:  
    Montana Historical Society Library (unknown).  
    Montana State Library (1966).  
Missoula: University of Montana Library (1909)—REGIONAL.

## NEBRASKA

Blair: Dana College, Dana-LIFE Library (1924).  
Crete: Doane College, Whitin Library (1944).  
Fremont: Midland Lutheran College Library (1924).  
Kearney: Kearney State College, Calvin T. Ryan Library (1962).  
Lincoln:  
    Nebraska Publications Clearinghouse, Nebraska Library Commission (1972).  
    Nebraska State Library (unknown).  
    University of Nebraska, Don L. Love Memorial Library (1907).  
Omaha:  
    Creighton University, Alumni Library (1964).  
    Omaha Public Library (1880).  
    University of Nebraska at Omaha, Gene Eppley Library (1939).  
Scottsbluff: Scottsbluff Public Library (1925).  
Wayne: Wayne State College, U.S. Conn Library (1970).

## NEVADA

Carson City:  
    Nevada State Library (unknown).  
    Nevada Supreme Court Library.  
Las Vegas:  
    Clark County Library District (pending).  
    University of Nevada at Las Vegas, James R. Dickinson Library (1959).



Reno:  
Nevada State Historical Society Library (1974).  
University of Nevada Library (1907)—REGIONAL

## NEW HAMPSHIRE

Concord:  
Franklin Pierce Law Center Library (1973).  
New Hampshire State Library (unknown).  
Durham: University of New Hampshire Library (1907).  
Franconia: Franconia College Library (1972).  
Hanover: Dartmouth College, Baker Library (1884).  
Henniker: New England College Library (1966).  
Manchester:  
Manchester City Library (1884).  
St. Anselm's College, Geisel Library (1963).  
Nashua: Nashua Public Library (1971).

## NEW JERSEY

Bayonne: Bayonne Free Public Library (1909).  
Bloomfield: Free Public Library of Bloomfield (1965).  
Bridgeton: Cumberland County Library (1966).  
Camden: Rutgers University-Camden Library (1966).  
Convent Station: College of St. Elizabeth, Mahoney Library (1938).  
East Orange: East Orange Public Library (1966).  
Elizabeth: Free Public Library of Elizabeth (1895).  
Glassboro: Glassboro State College, Savitz Learning Resource Center (1963).  
Hackensack: Johnson Free Public Library (1966).  
Irvington: Free Public Library of Irvington (1966).  
Jersey City:  
Free Public Library of Jersey City (1879).  
Jersey City State College, Forrest A. Irwin Library (1963).  
Madison: Drew University, Rose Memorial Library (1939).  
Mahwah: Ramapo College Library (1971).  
Mount Holly: Burlington County Library (1966).  
New Brunswick:  
Free Public Library (1908).  
Rutgers University Library (1907).  
Newark:  
Newark Public Library (1906)—REGIONAL.  
Rutgers-The State University, John Cotton Dana Library (1966).  
Passaic: Passaic Public Library (1964).  
Plainfield: Plainfield Public Library (1971).  
Princeton: Princeton University Library (1884).  
Rutherford: Fairleigh Dickinson University, Messler Library (1953).  
Shrewsbury: Monmouth County Library (1968).  
South Orange: Seton Hall University, McLaughlin Library (1947).  
Teaneck: Fairleigh Dickinson University Library, Teaneck Campus (1963).  
Toms River: Ocean County College Learning Resources Center (1966).  
Trenton:  
New Jersey State Library, Law and Reference Bureau, Department of Education (unknown).  
Trenton Free Public Library (1902).  
Union: Newark State College, Nancy Thompson Library (1973).  
Upper Montclair: Montclair State College, Harry A. Sprague Library (1967).  
Wayne: Wayne Public Library (1972).  
West Long Branch: Monmouth College, Guggenheim Memorial Library (1963).  
Woodbridge: Free Public Library of Woodbridge (1965).

## NEW MEXICO

Albuquerque:  
University of New Mexico, Medical Science Library (1973).  
University of New Mexico, School of Law Library (1973).  
University of New Mexico, Zimmerman Library (1896)—REGIONAL.  
Hobbs: New Mexico Junior College, Pannell Library (1969).  
Las Cruces: New Mexico State University Library (1907).  
Las Vegas: New Mexico Highlands University, Donnelly Library (1913).  
Portales: Eastern New Mexico University Library (1962).  
Santa Fe:  
New Mexico State Library (1960)—REGIONAL.  
Supreme Court Law Library (unknown).  
Silver City: Western New Mexico University, Miller Library (1972).

## NEW YORK

Albany:  
New York State Library (unknown)—REGIONAL.  
State University of New York at Albany Library (1964).  
Auburn: Seymour Library (1972).  
Bayside: Queensborough Community College Library (1972).  
Binghamton: State University of New York at Binghamton Library (1962).  
Brockport: State University of New York, Drake Memorial Library (1967).  
Bronx:  
Herbert H. Lehman College Library (1967).  
New York Public Library, Mott Haven Branch (1973).  
Bronxville: Sarah Lawrence College Library (1969).  
Brooklyn:  
Brooklyn College Library (1936).  
Brooklyn Public Library (1908).  
Polytechnic Institute of Brooklyn, Spicer Library (1963).  
Pratt Institute Library (1891).  
State University of New York, Downstate Medical Center Library (1958).  
Buffalo:  
Buffalo and Erie County Public Library (1895).  
State University of New York at Buffalo, Lockwood Memorial Library (1963).  
Canton: St. Lawrence University, Owen D. Young Library (1920).  
Corning: Corning Community College, Arthur A. Houghton, Jr. Library (1963).  
Cortland: State University of New York, College at Cortland, Memorial Library (1964).  
Delhi: State University Agricultural and Technical College Library (1970).  
Douglaston: Cathedral College Library (1971).  
East Islip: East Islip Public Library (1973).  
Elmira: Elmira College, Gannett-Tripp Learning Center (1956).  
Farmingdale: State University Agricultural and Technical Institute at Farmingdale Library (1917).  
Flushing: Queens College, Paul Klapper Library (1939).  
Garden City:  
Adelphi University, Swirbul Library (1966).  
Nassau Library System (1965).  
Geneseo: State University College, Milne Library (1967).  
Greenvale: C. W. Post College, B. Davis Schwartz Memorial Library (1964).  
Hamilton: Colgate University Library (1902).  
Hempstead: Hofstra University Library (1964).  
Huntington: Huntington Public Library (1966).



**Ithaca:**  
 Cornell University Library (1907).  
 New York State Colleges of Agriculture and Home Economics, Albert R. Mann Library (1943).

**Jamaica:**  
 Queens Borough Public Library (1926).  
 St. John's University Library (1956).

**Kings Point:** U.S. Military Academy Library (1962).

**Mount Vernon:** Mount Vernon Public Library (1962).

**New Paltz:** State University College Library (1965).

**New York City:**  
 City University of New York, City College Library (1884).  
 College of Insurance, Ecker Library (1965).  
 Columbia University Libraries (1882).  
 Cooper Union Library (1930).  
 Fordham University Library (1937).  
 New York Law Institute Library (1909).  
 New York Public Library (Astor Branch) (1907).  
 New York Public Library (Lenox Branch) (1884).  
 New York University Law Library (1973).  
 New York University Libraries (1967).  
 State University of New York, Maritime College Library (1947).

**Newburgh:** Newburgh Free Library (1909).

**Oakdale:** Dowling College Library (1965).

**Oneonta:** State University College, James M. Milne Library (1966).

**Oswego:** State University College, Penfield Library (1966).

**Plattsburgh:** State University College, Benjamin F. Feinberg Library (1967).

**Potsdam:**  
 Clarkson College of Technology, Harriet Call Burnap Memorial Library (1938).  
 State University College, Frederick W. Crumb Memorial Library (1964).

**Poughkeepsie:** Vassar College Library (1943).

**Purchase:** State University of New York, College at Purchase Library (1969).

**Rochester:**  
 Rochester Public Library (1963).  
 University of Rochester Library (1880).

**St. Bonaventure:** St. Bonaventure University, Friedsam Memorial Library (1938).

**Saratoga Springs:** Skidmore College Library (1964).

**Schenectady:** Union College, Schaffer Library (1901).

**Southampton:** Southampton College Library (1973).

**Staten Island:** Wagner College, Horrmann Library (1953).

**Stony Brook:** State University of New York at Stony Brook Library (1963).

**Syracuse:** Syracuse University Library (1878).

**Troy:** Troy Public Library (1869).

**Utica:** Utica Public Library (1885).

**West Point:** U.S. Military Academy Library (unknown).

**Yonkers:** Yonkers Public Library (1910).

## NORTH CAROLINA

**Asheville:** University of North Carolina at Asheville (1965).

**Boiling Springs:** Gardner-Webb College, Dover Memorial Library (1974).

**Boone:** Appalachian State University Library (1963).

**Buies Creek:** Campbell College, Carrie Rich Memorial Library (1965).

**Chapel Hill:** University of North Carolina Library (1884)—REGIONAL.

**Charlotte:**  
 Public Library of Charlotte and Mecklenburg County (1964).  
 Queens College, Everett Library (1927).

**University of North Carolina at Charlotte,** Atkins Library (1964).

**Cullowhee:** Western Carolina University, Hunter Library (1953).

**Davidson:** Davidson College, Hugh A. & Jane Grey Memorial Library (1893).

**Durham:**  
 Duke University, William R. Perkins Library (1890).  
 North Carolina Central University, James E. Shepard Memorial Library (1973).

**Elon College:** Elon College Library (1971).

**Fayetteville:** Fayetteville State University, Chestnutt Library (1971).

**Greensboro:**  
 North Carolina Agricultural and Technical State University, F. D. Bluford Library (1937).  
 University of North Carolina at Greensboro, Walter Clinton Jackson Library (1963).

**Greenville:** East Carolina University, J. Y. Joyner Library (1951).

**Laurinburg:** St. Andrews Presbyterian College, DeTamble Library (1969).

**Lexington:** Davidson County Public Library System (1971).

**Mount Olive:** Mount Olive College, Moye Library (1971).

**Murfreesboro:** Chowan College, Whitaker Library (1963).

**Pembroke:** Pembroke State University Library (1965).

**Raleigh:**  
 North Carolina State Library (unknown).  
 North Carolina State University, R. H. Hill Library (1923).  
 North Carolina Supreme Court Library (1972).  
 Wake County Public Libraries (1969).

**Rocky Mount:** North Carolina Wesleyan College Library (1969).

**Salisbury:** Catawba College Library (1925).

**Wilmington:** University of North Carolina at Wilmington, William M. Randall Library (1965).

**Wilson:** Atlantic Christian College, Clarence L. Hardy Library (1930).

**Winston-Salem:**  
 Forsyth County Public Library System (1954).  
 Wake Forest University, Z. Smith Reynolds Library (1902).

## NORTH DAKOTA

**Bismarck:**  
 State Historical Society of North Dakota (1907).  
 North Dakota State Law Library (unknown).  
 North Dakota State Library Commission Library (1971).  
 Veterans Memorial Public Library (1968).

**Dickinson:** Dickinson State College Library (1968).

**Fargo:**  
 Fargo Public Library (1964).  
 North Dakota State University Library (1907)—REGIONAL.

**Grand Forks:** University of North Dakota, Chester Fritz Library (1890).

**Minot:** Minot State College, Memorial Library (1925).

**Valley City:** State College Library (1913).

## OHIO

**Ada:** Ohio Northern University College of Law, J. P. Taggart Library (1965).

**Akron:**  
 Akron Public Library (1952).  
 University of Akron Library (1963).

**Alliance:** Mount Union College Library (1888).

**Ashland:** Ashland College Library (1938).



Athens: Ohio University Library (1886).  
 Batavia: Clermont General and Technical College Library (1973).  
 Bluffton: Bluffton College, Musselman Library (1951).  
 Bowling Green: Bowling Green State University Library (1933).  
 Canton: Malone College, Everett L. Cattell Library (1970).  
 Chardon: Geauga County Public Library (1971).  
 Cincinnati:  
   Public Library of Cincinnati and Hamilton County (1884).  
   University of Cincinnati Library (1929).  
 Cleveland:  
   Case Western Reserve University, Freiburger Library (1913).  
   Cleveland Heights-University Heights Public Library (1970).  
   Cleveland Public Library (1886).  
   Cleveland State University Library (1966).  
   John Carroll University, Grasselli Library (1963).  
   Municipal Reference Library (1970).  
 Columbus:  
   Capital University Library (1968).  
   Columbus Public Library (1885).  
   Ohio State Library (unknown)—REGIONAL.  
   Ohio State University Library (1907).  
   Ohio Supreme Court Law Library (1973).  
 Dayton:  
   Dayton and Montgomery County Public Library (1909).  
   University of Dayton, Albert Emanuel Library (1969).  
   Wright State University Library (1965).  
 Delaware: Ohio Wesleyan University, L. A. Beeghly Library (1845).  
 Elyria: Elyria Public Library (1966).  
 Findlay: Findlay College, Shafer Library (1969).  
 Gambier: Kenyon College Library (1873).  
 Granville: Denison University Library (1884).  
 Hiram: Hiram College, Teachout-Price Memorial Library (1874).  
 Kent: Kent State University Library (1962).  
 Marietta: Marietta College, Dawes Memorial Library (1884).  
 Middletown: Miami University at Middletown, Gardner-Harvey Library (1970).  
 New Concord: Muskingum College Library (1966).  
 Oberlin: Oberlin College Library (1858).  
 Oxford: Miami University, Alumni Library (1909).  
 Portsmouth: Portsmouth Public Library (unknown).  
 Rio Grande: Rio Grande College, Jeanette Albiez Davis Library (1966).  
 Springfield: Warder Public Library (1884).  
 Steubenville:  
   College of Steubenville, Starvaggi Memorial Library (1971).  
   Public Library of Steubenville and Jefferson County (1950).  
 Tiffin: Heidelberg College, Beeghly Library (1964).  
 Toledo:  
   Toledo-Lucas County Public Library (1884).  
   University of Toledo Library (1963).  
 Westerville: Otterbein College, Centennial Library (1967).  
 Wooster: College of Wooster, Andrews Library (1966).  
 Youngstown:  
   Public Library of Youngstown and Mahoning County (1923).  
   Youngstown State University Library (1971).

## OKLAHOMA

Ada: East Central State College, Linscheid Library (1914).  
 Alva: Northwestern State College Library (1907).  
 Bartlesville: U.S. Bureau of Mines, Energy Research Center Library (1962).

Bethany: Bethany Nazarene College, R. T. Williams Library (1971).  
 Durant: Southeastern State College Library (1929).  
 Edmond: Central State University Library (1934).  
 Enid: Public Library of Enid and Garfield County (1908).  
 Langston: Langston University, G. Lamar Harrison Library (1941).  
 Muskogee: Muskogee Public Library (1971).  
 Norman: University of Oklahoma Libraries (1893).  
 Oklahoma City:  
   Oklahoma City University Library (1963).  
   Oklahoma Department of Libraries (1893)—REGIONAL.  
 Shawnee: Oklahoma Baptist University Library (1933).  
 Stillwater: Oklahoma State University Library (1907).  
 Tahlequah: Northeastern State College, John Vaughan Library (1923).  
 Tulsa:  
   Tulsa City-County Library (1963).  
   University of Tulsa, McFarlin Library (1929).  
 Weatherford: Southwestern State College Library (1958).

## OREGON

Ashland: Southern Oregon College Library (1953).  
 Corvallis: Oregon State University Library (1907).  
 Eugene: University of Oregon Library (1883).  
 Forest Grove: Pacific University Library (1897).  
 La Grande: Eastern Oregon College, Walter M. Pierce Library (1954).  
 McMinnville: Linfield College, Northup Library (1965).  
 Monmouth: Oregon College of Education Library (1967).  
 Portland:  
   Department of the Interior, Bonneville Power Administration Library (1962).  
   Lewis and Clark College, Aubrey R. Watzek Library (1967).  
   Library Association of Portland (1884).  
   Portland State University Library (1963)—REGIONAL.  
   Reed College Library (1912).  
 Salem:  
   Oregon State Library (unknown).  
   Oregon Supreme Court Library (1974).  
   Willamette University Library (1969).

## PENNSYLVANIA

Allentown: Muhlenberg College, Haas Library (1939).  
 Altoona: Altoona Public Library (1969).  
 Bethlehem: Lehigh University, Linderman Library (1876).  
 Carlisle: Dickinson College, Boyd Lee Spahr Library (1947).  
 Cheyney: Cheyney State College, Leslie Pinckney Hill Library (1947).  
 Collegeville: Ursinus College, Myrin Library (1963).  
 Doylestown: Bucks County Free Library, Center County Library (1970).  
 East Stroudsburg: East Stroudsburg State College, Kemp Library (1966).  
 Erie: Erie Public Library (1897).  
 Greenville: Thiel College, Langenheim Memorial Library (1963).  
 Harrisburg: State Library of Pennsylvania (unknown)—REGIONAL.  
 Haverford: Haverford College Library (1897).  
 Hazleton: Hazleton Area Public Library (1964).  
 Indiana: Indiana University of Pennsylvania, Rhodes R. Stabley Library (1962).  
 Johnstown: Cambria County Glosser Memorial Library (1965).



Lancaster: Franklin and Marshall College, Fackenthal Library (1895).

Lewisburg: Bucknell University, Ellen Clarke Bertrand Library (1963).

Mansfield: Mansfield State College Library (1968).

Meadville: Allegheny College, Reis Library (1907).

Millersville: Millersville State College, Ganser Library (1966).

Monessen: Monessen Public Library (1969).

New Castle: New Castle Free Public Library (1963).

Newtown: Bucks County Community College Library (1968).

Norristown: Montgomery County-Norristown Public Library (1969).

Philadelphia:

Drexel University Library (1963).

Free Library of Philadelphia (1897).

Temple University, Samuel Paley Library (1947).

University of Pennsylvania Library (1886).

U.S. Court of Appeals for Third Circuit Library (1973).

Pittsburgh:

Carnegie Library of Pittsburgh, Allegheny Regional Branch (1924).

Carnegie Library of Pittsburgh (1895).

University of Pittsburgh, Hillman Library (1910).

U.S. Bureau of Mines, Pittsburgh Research Center Library (1962).

Pottsville: Pottsville Free Public Library (1967).

Reading: Reading Public Library (1901).

Scranton: Scranton Public Library (1895).

Shippensburg: Shippensburg State College, Ezra Lehman Memorial Library (1973).

Slippery Rock: Slippery Rock State College, Maltby Library (1965).

Swarthmore: Swarthmore College Library (1923).

University Park: Pennsylvania State University Library (1907).

Villanova: Villanova University, School of Law Library (1964).

Warren: Warren Library Association, Warren Public Library (1885).

Washington: Washington and Jefferson College, Memorial Library (1884).

Waynesburg: Waynesburg College Library (1964).

West Chester: West Chester State College, Francis Harvey Green Library (1967).

Wilkes-Barre: King's College, Corgan Library (1949).

Williamsport: Lycoming College Library (1970).

York: York Junior College Library (1963).

Youngwood: Westmoreland County Community College, Learning Resource Center (1972).

## PUERTO RICO

Mayaguez: University of Puerto Rico, Mayaguez Campus Library (1928).

Ponce: Catholic University of Puerto Rico Library (1966).

Rio Piedras: University of Puerto Rico General Library (1928).

## RHODE ISLAND

Kingston: University of Rhode Island Library (1907).

Newport: U.S. Naval War College Library (1963).

Providence:

Brown University Library (unknown).

Providence College, Phillips Memorial Library (1969).

Providence Public Library (1884).

Rhode Island College, James P. Adams Library (1965).

Rhode Island State Library (before 1895).

Warwick: Warwick Public Library (1966).

Westerly: Westerly Public Library (1909).

## SOUTH CAROLINA

Charleston:

Baptist College at Charleston Library (1967).

College of Charleston Library (1869).

The Citadel Memorial Library (1962).

Clemson: Clemson University Library (1893).

Columbia:

Benedict College, Starks Library (1969).

Columbia College, Edens Library (1966).

South Carolina State Library (before 1895).

University of South Carolina, Undergraduate Library (1884).

Conway: University of South Carolina, Coastal Carolina Regional Campus Library (1974).

Due West: Erskine College, McCain Library (1968).

Florence:

Florence County Library (1967).

Francis Marion College, James A. Rogers Library (1970).

Greenville:

Furman University Library (1962).

Greenville County Library (1966).

Greenwood: Lander College Library (1967).

Orangeburg: South Carolina State College, Whittaker Library (1953).

Rock Hill: Winthrop College, Dacus Library (1896).

Spartanburg: Spartanburg County Public Library (1967).

## SOUTH DAKOTA

Aberdeen: Northern State College Library (1963).

Brookings: South Dakota State University, Lincoln Memorial Library (1889).

Pierre: South Dakota State Library (1973).

Rapid City:

Rapid City Public Library (1963).

South Dakota School of Mines and Technology Library (1963).

Sioux Falls:

Augustana College, Mikkelsen Library and Learning Resources Center (1969).

Sioux Falls Public Library (1903).

Spearfish: Black Hills State College Library (1942).

Vermillion: University of South Dakota, I. D. Weeks Library (1889).

Yankton: Yankton College Library (1904).

## TENNESSEE

Bristol: King College Library (1970).

Chattanooga: Chattanooga Public Library (1907).

Clarksville: Austin Peay State University, Felix G. Woodward Library (1945).

Cleveland: Cleveland State Community College Library (1973).

Columbia: Columbia State Community College, Finney Memorial Library (1973).

Cookeville: Tennessee Technological University, Jere Whitson Memorial Library (1969).

Jackson: Lambuth College, Luther L. Gobbel Library (1967).

Jefferson City: Carson-Newman College Library (1964).

Johnson City: East Tennessee State University, Sherrod Library (1942).

Knoxville:

Public Library of Knoxville and Knox County, Lawson McGhee Library (1973).

University of Tennessee Law Library (1971).

University of Tennessee Library (1907).



Martin: University of Tennessee at Martin Library (1957).  
 Memphis:  
   Memphis and Shelby County Public Library and Information Center (1896).  
   Memphis State University, John W. Brister Library (1966).  
 Morristown: Morristown College, Carnegie Library (1970).  
 Murfreesboro: Middle Tennessee State University, Andrew L. Todd Library (1912).  
 Nashville:  
   Fisk University Library (1965).  
   Joint University Libraries (1884).  
   Public Library of Nashville and Davidson County (1884).  
   Tennessee State Library and Archives, State Library Division (unknown).  
   Tennessee State University, Martha M. Brown Memorial Library (1972).  
 Sewanee: University of the South, Jesse Ball duPont Library (1873).

## TEXAS

Abilene: Hardin-Simmons University Library (1940).  
 Arlington:  
   Arlington Public Library (1970).  
   University of Texas at Arlington Library (1963).  
 Austin:  
   Texas State Law Library (1972).  
   Texas State Library (unknown)—REGIONAL.  
   University of Texas at Austin Library (1884).  
   University of Texas, Lyndon B. Johnson School of Public Affairs Library (1966).  
   University of Texas, School of Law Library (1965).  
 Baytown: Lee College Library (1970).  
 Beaumont: Lamar University Library (1957).  
 Brownwood: Howard Payne College, Walker Memorial Library (1964).  
 Canyon: West Texas State University Library (1928).  
 College Station: Texas Agricultural and Mechanical University Library (1907).  
 Commerce: East Texas State University Library (1937).  
 Corsicana: Navarro Junior College Library (1965).  
 Dallas:  
   Bishop College, Zale Library (1966).  
   Dallas Baptist College Library (1967).  
   Dallas Public Library (1900).  
   Southern Methodist University, Fondren Library (1925).  
 Denton: North Texas State University Library (1948).  
 Edinburg: Pan American University Library (1959).  
 El Paso:  
   El Paso Public Library (1906).  
   University of Texas at El Paso Library (1966).  
 Fort Worth:  
   Fort Worth Public Library (1905).  
   Texas Christian University, Mary Couets Burnett Library (1916).  
 Galveston: Rosenberg Library (1909).  
 Houston:  
   Houston Public Library (1884).  
   Rice University, Fondren Library (1967).  
   University of Houston Library (1957).  
 Huntsville: Sam Houston State University, Estill Library (1949).  
 Kingsville: Texas Arts and Industries University Library (1944).  
 Lake Jackson: Brazosport College Library (1969).  
 Laredo: Laredo Junior College, Harold R. Yeary Library (1970).  
 Longview: Nicholson Memorial Public Library (1961).

Lubbock: Texas Tech University Library (1935)—REGIONAL.  
 Marshall: Wiley College, Cole Library (1962).  
 Nacogdoches: Stephen F. Austin State University Library (1965).  
 Plainview: Wayland Baptist College, Van Howeling Memorial Library (1963).  
 Richardson: University of Texas at Dallas Library (1972).  
 San Angelo: Angelo State University, Porter Henderson Library (1964).  
 San Antonio:  
   San Antonio College Library (1972).  
   San Antonio Public Library, Business and Science Department (1899).  
   St. Mary's University Library (1964).  
   Trinity University Library (1964).  
   University of Texas at San Antonio Library (1973).  
 San Marcos: Southwest Texas State University Library (1955).  
 Seguin: Texas Lutheran College, Blumberg Memorial Library (1970).  
 Sherman: Austin College, Arthur Hopkins Library (1963).  
 Texarkana: Texarkana Community College, Palmer Memorial Library (1963).  
 Victoria: University of Houston, Victoria Center Library (1973).  
 Waco: Baylor University Library (1905).  
 Wichita Falls: Midwestern University, Moffett Library (1963).

## UTAH

Cedar City: Southern Utah State College Library (1964).  
 Ephraim: Snow College, Lucy A. Phillips Library (1963).  
 Logan: Utah State University, Merrill Library and Learning Resources Center (1907)—REGIONAL.  
 Ogden: Weber State College Library (1962).  
 Provo:  
   Brigham Young University Library (1908).  
   Brigham Young University, Law Library (1972).  
 Salt Lake City:  
   University of Utah, Law Library (1966).  
   University of Utah, Eccles Medical Sciences Library (1970).  
   University of Utah, Marriott Library (1893).  
   Utah State Library Commission, Documents Library (unknown).

## VERMONT

Burlington: University of Vermont, Bailey Library (1907).  
 Castleton: Castleton State College, Calvin Coolidge Library (1969).  
 Johnson: Johnson State College, John Dewey Library (1955).  
 Lyndonville: Lyndon State College, Samuel Reed Hall Library (1969).  
 Middlebury: Middlebury College, Egbert Starr Library (1884).  
 Montpelier: Vermont Department of Libraries (before 1895).  
 Northfield: Norwich University Library (1908).  
 Putney: Windham College, Dorothy Culbertson Marvin Memorial Library (1965).

## VIRGIN ISLANDS

St. Croix: Christiansted Public Library (1974).  
 St. Thomas:  
   College of the Virgin Islands, Ralph M. Paiewonsky Library (1973).  
   St. Thomas Public Library (1968).



## VIRGINIA

- Blacksburg: Virginia Polytechnic Institute, Newman Library (1907).  
Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).  
Charlottesville:  
University of Virginia, Alderman Library (1910)—REGIONAL.  
University of Virginia Law Library (1964).  
Chesapeake: Chesapeake Public Library System (1970).  
Danville: Danville Community College Library (1969).  
Emory: Emory and Henry College Library (1884).  
Fairfax: George Mason College of the University of Virginia, Fenwick Library (1960).  
Fredericksburg: Mary Washington College, E. Lee Trinkle Library (1940).  
Hampden-Sydney: Hampden-Sydney College, Eggleston Library (1891).  
Harrisonburg: Madison College, Madison Memorial Library (1973).  
Hollins College: Hollins College, Fishburn Library (1967).  
Lexington:  
Virginia Military Institute, Preston Library (1874).  
Washington and Lee University, Cyrus Hall McCormick Library (1910).  
Martinsville: Patrick Henry Community College Library (1971).  
Norfolk:  
Armed Forces Staff College Library (1963).  
Norfolk Public Library (1895).  
Old Dominion University, Hughes Memorial Library (1963).  
Petersburg: Virginia State College, Johnston Memorial Library (1907).  
Quantico:  
Federal Bureau of Investigation Academy Library (1970).  
Marine Corps Schools, James Carson Breckinridge Library (1967).  
Richmond:  
State Law Library (1973).  
University of Richmond, Boatright Memorial Library (1900).  
U.S. Court of Appeals for Fourth Circuit Library (1973).  
Virginia Commonwealth University, James Branch Cabell Library (1971).  
Virginia State Library (unknown).  
Roanoke: Roanoke Public Library (1964).  
Salem: Roanoke College Library (1886).  
Williamsburg: College of William and Mary, Swem Library (1936).  
Wise: Clinch Valley College, John Cook Wyllie Library (1971).

## WASHINGTON

- Bellingham: Western Washington State College, Wilson Library (1963).  
Cheney: Eastern Washington State College Library (1966).  
Ellensburg: Central Washington State College Library (1962).  
Everett: Everett Public Library (1914).  
Olympia:  
Evergreen State College Library (1972).  
Washington State Library (unknown)—REGIONAL.  
Port Angeles: Port Angeles Public Library (1965).  
Pullman: Washington State University Library (1907).  
Seattle:  
Seattle Public Library (1908).  
University of Washington Library (1890).  
University of Washington, School of Law Library (1969).

Spokane: Spokane Public Library (1910).

Tacoma:

Tacoma Public Library (1894).

University of Puget Sound, Collins Memorial Library (1938).

Vancouver: Fort Vancouver Regional Library (1962).

Walla Walla: Whitman College, Penrose Memorial Library (1890).

## WEST VIRGINIA

- Athens: Concord College Library (1924).  
Bluefield: Bluefield State College Library (1972).  
Charleston:  
Kanawha County Public Library (1952).  
West Virginia Department of Archives and History Library (unknown).  
Elkins: Davis and Elkins College Library (1913).  
Fairmont: Fairmont State College Library (1884).  
Glenville: Glenville State College, Robert F. Kidd Library (1966).  
Huntington: Marshall University Library (1925).  
Institute: West Virginia State College Library (1907).  
Morgantown: West Virginia University Library (1907)—REGIONAL.  
Salem: Salem College Library (1921).  
Shepherdstown: Shepherd College Library (1971).  
Weirton: Mary H. Weir Public Library (1963).

## WISCONSIN

- Appleton: Lawrence University, Samuel Appleton Library (1869).  
Beloit: Beloit College Libraries (1888).  
Eau Claire: University of Wisconsin-Eau Claire, William D. McIntyre Library (1951).  
Fond du Lac: Fond du Lac Public Library (1966).  
Green Bay: University of Wisconsin at Green Bay Library (1968).  
La Crosse:  
La Crosse Public Library (1883).  
University of Wisconsin-La Crosse, Murphy Library (1965).  
Madison:  
Department of Public Instruction, Division for Library Services, Reference and Loan Library (1965).  
Madison Public Library (1965).  
State Historical Society Library (1870)—REGIONAL.  
University of Wisconsin, Memorial Library (1939).  
Wisconsin State Library (unknown).  
Milwaukee:  
Alverno College Library (1971).  
Milwaukee County Law Library (1934).  
Milwaukee Public Library (1961)—REGIONAL.  
Mount Mary College Library (1964).  
Oklahoma Neighborhood Library (1965).  
University of Wisconsin-Milwaukee Library (1960).  
Oshkosh: University of Wisconsin-Oshkosh, Forrest R. Polk Library (1956).  
Platteville: University of Wisconsin-Platteville, Karrmann Library (1964).  
Racine: Racine Public Library (1898).  
River Falls: University of Wisconsin-River Falls, Chalmer Davee Library (1962).  
Stevens Point: University of Wisconsin-Stevens Point, Learning Resources Center (1951).



**Superior:**

**Superior Public Library (1908).**

**University of Wisconsin-Superior, Jim Dan Hill Library (1935).**

**Waukesha: Waukesha Public Library (1966).**

**Wausau: Wausau Public Library (1971).**

**Whitewater: University of Wisconsin-Whitewater, Harold Andersen Library (1963).**

## **WYOMING**

**Casper: Natrona County Public Library (1929).**

**Cheyenne: Wyoming State Library (unknown).**

**Laramie: University of Wyoming, Coe Library (1907).**

**Powell: Northwest Community College Library (1967).**

**Riverton: Central Wyoming College Library (1969).**

**Rock Springs: Western Wyoming College Library (1969).**

**Sheridan: Sheridan College, Mary Brown Kooi Library (1963).**



## APPENDIX B. LIST OF FIELD OFFICES OF THE U.S. DEPARTMENT OF COMMERCE

**ALBUQUERQUE, NEW MEXICO 87101**  
U.S. Courthouse—Room 316  
Area Code 505 Tel. 843-2386

**ANCHORAGE, ALASKA 99501**  
412 Hill Building  
632 Sixth Avenue  
Area Code 907 Tel. 265-4597/8

**ATLANTA, GEORGIA 30309**  
Suite 523, 1401 Peachtree St., N.E.  
Area Code 404 Tel. 526-6000

**BALTIMORE, MARYLAND 21202**  
415 U.S. Customhouse  
Gay and Lombard Streets  
Area Code 301 Tel. 962-3560

**BIRMINGHAM, ALABAMA 35205**  
Suite 200-201  
908 South 20th Street  
Area Code 205 Tel. 325-3327

**BOSTON, MASSACHUSETTS 02116**  
10th Floor, 441 Stuart Street  
Area Code 617 Tel. 223-2312

**BUFFALO, NEW YORK 14202**  
910 Federal Building  
111 West Huron Street  
Area Code 716 Tel. 842-3208

**CHARLESTON, WEST VIRGINIA 25301**  
3000 New Federal Office Building  
500 Quarrier Street  
Area Code 304 Tel. 343-1375

**CHEYENNE, WYOMING 82001**  
6022 O'Mahoney Federal Center  
2120 Capitol Avenue  
Area Code 307 Tel. 778-2151

**CHICAGO, ILLINOIS 60604**  
Room 1406, Mid Continental Plaza Building  
55 East Monroe Street  
Area Code 312 Tel. 353-4450

**CINCINNATI, OHIO 45202**  
8028 Federal Office Building  
550 Main Street  
Area Code 513 Tel. 684-2944

**CLEVELAND, OHIO 44114**  
Room 600, 666 Euclid Avenue  
Area Code 216 Tel. 522-4750

**COLUMBIA, SOUTH CAROLINA 29204**  
2611 Forest Drive  
Area Code 803 Tel. 765-5345

**DALLAS, TEXAS 75202**  
Room 3E7, 1100 Commerce Street  
Area Code 214 Tel. 749-1515

**DENVER, COLORADO 80202**  
Room 161, New Customhouse  
19th and Stout Streets  
Area Code 303 Tel. 837-3246

**DES MOINES, IOWA 50309**  
609 Federal Building  
210 Walnut Street  
Area Code 515 Tel. 284-4222

**DETROIT, MICHIGAN 48226**  
445 Federal Building  
Area Code 313 Tel. 226-6063

**GREENSBORO, NORTH CAROLINA 27402**  
258 Federal Building  
West Market Street, P.O. Box 1950  
Area Code 919 Tel. 275-9345

**HARTFORD, CONNECTICUT 06103**  
Room 610-B, Federal Office Building  
450 Main Street  
Area Code 203 Tel. 244-3530

**HONOLULU, HAWAII 96813**  
286 Alexander Young Building  
1015 Bishop Street  
Area Code 808 Tel. 546-8694

**HOUSTON, TEXAS 77002**  
1017 Old Federal Building  
201 Fannin Street  
Area Code 713 Tel. 226-4231

**KANSAS CITY, MISSOURI 64106**  
Room 1840, 601 East 12th Street  
Area Code 816 Tel. 374-3142

**LOS ANGELES, CALIFORNIA 90024**  
11201 Federal Building  
11000 Wilshire Blvd.  
Area Code 213 Tel. 824-7591

**MEMPHIS, TENNESSEE 38103**  
Room 710, 147 Jefferson Avenue  
Area Code 901 Tel. 534-3213

**MIAMI, FLORIDA 33130**  
Room 821, City National Bank Building  
25 West Flagler Street  
Area Code 305 Tel. 350-5267

**MILWAUKEE, WISCONSIN 53203**  
Straus Building  
238 West Wisconsin Avenue  
Area Code 414 Tel. 224-3473

**MINNEAPOLIS, MINNESOTA 55401**  
306 Federal Building  
110 South Fourth Street  
Area Code 612 Tel. 725-2133

**NEWARK, NEW JERSEY 07102**  
4th Floor, Gateway Building  
Area Code 201 Tel. 645-6214

**NEW ORLEANS, LOUISIANA 70130**  
432 International Trade Mark  
No. 2 Canal Street  
Area Code 504 Tel. 527-6546

**NEW YORK, NEW YORK 10007**  
41st Floor, Federal Office Building  
26 Federal Plaza, Foley Square  
Area Code 212 Tel. 264-0600

**PHILADELPHIA, PENNSYLVANIA 19106**  
10112 Federal Building  
600 Arch Street  
Area Code 215 Tel. 597-2850

**PHOENIX, ARIZONA 85004**  
508 Greater Arizona Savings Bldg.  
112 North Central  
Area Code 602 Tel. 261-3285

**PITTSBURGH, PENNSYLVANIA 15222**  
431 Federal Building  
1000 Liberty Avenue  
Area Code 412 Tel. 644-2850

**PORTLAND, OREGON 97205**  
Suite 521, Pittock Block  
921 S.W. Washington Street  
Area Code 503 Tel. 221-3001

**RENO, NEVADA 89502**  
2028 Federal Building  
300 Booth Street  
Area Code 702 Tel. 784-5203

**RICHMOND, VIRGINIA 23240**  
8010 Federal Building  
400 North 8th Street  
Area Code 804 Tel. 782-2246

**ST. LOUIS, MISSOURI 63105**  
Chromalloy Building  
120 South Central Avenue  
Area Code 314 Tel. 622-4243

**SALT LAKE CITY, UTAH 84138**  
1203 Federal Building  
125 South State Street  
Area Code 801 Tel. 524-5116

**SAN FRANCISCO, CALIFORNIA 94102**  
Federal Building, Box 36013  
450 Golden Gate Avenue  
Area Code 415 Tel. 556-5860



**SAN JUAN, PUERTO RICO 00902**  
**Room 100, Post Office Building**  
**Phone: 723-4640**

**SAVANNAH, GEORGIA 31402**  
**235 U.S. Courthouse & Post Office Bldg.**  
**125-29 Bull Street**  
**Area Code 912 Tel. 232-4204**

**SEATTLE, WASHINGTON 98109**  
**Room 706, Lake Union Bldg.**  
**1700 Westlake Avenue North**  
**Area Code 206 Tel. 442-5615**



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